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FOREWORD

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The battlefield entails fighting, wounding and killing one another, using the most advanced weapons technology and the best training available to the belligerents!

This action is countered by one's own forces using best technology, advanced weapon systems and training to try to prevent supremacy by the enemy. One of the weapons available to one's own forces is operational medicine. Operational Medicine should therefore also entail the use of the most advanced technology and resources available to save as many lives as possible, with operational medical staff as battle winners through competent pre-hospital care, in-transit care during tactical evacuation, in care in deployed and base hospitals and aeromedical evacuation (1).

Operational medicine should not only include saving lives, but also saving limbs and eyesight through a seamless system of force health protection, force health sustainment and force health improvement from point of wounding to rehabilitation through coordinated clinical approaches.

To achieve this, operational medicine, similar to the *weapons* used to counter the enemy, should be advanced, include cutting edge scientifically-based technology, and should be practiced by skilled personnel. It should be timeously available, mobile, flexible, economical in effort and sustained.

The purpose of operational medicine remains the countering of the enemy's weapon's impact on the human body through appropriate interventions. Today, as in

years past, non-compressible haemorrhage and junctional trauma remain the main killers on the battlefield (1) and measures should focus on addressing these issues. The best counteraction to bleeding is still to stop the bleeding! For this purpose, various interventions are available:

- Skilled early emergency care interventions to sustain physiological functions (2);
- Control bleeding through external actions (mainly aimed at the compressible bleeding) such as the liberal use of tourniquets and haemostatic dressings;
- Damage control surgery and damage control resuscitation techniques (3);
- Skilled and competent human resources.

Unfortunately, very few of these interventions are presently readily available in the African Battle Space and in the SAMHS arsenal.

The availability of early emergency care interventions is pivotal to delivering a salvageable casualty to the military surgeon both in the field and at base. These include rapid catastrophic bleeding control, definitive airway interventions and maintenance of fluid balance, taking cognisance of hypovolemic fluid resuscitation principles. Unfortunately, we are presently lacking these weapons with the SAMHS yet to introduce battlefield tourniquets or haemostatic dressings into the soldier packs, and making advance infusion equipment available to the field medic.

In Operational Medicine, time is of the essence, which is why battlefield vehicle extrication and effective decontamination are such critical interventions. The longer we take to provide this the lower the chances of survival (3) . Rapid, effective evacuation, with in-transit care, to appropriate care is critical (4). The use of consultant led helicopter primary retrieval teams has proved to be essential in the survival chain in the present international conflict theatres (1) .

We should also investigate the concepts of our evacuation lines. Is there still a role for the pure Level 1 Resuscitation Capability (Role 2) in managing trauma? Currently, the model of advanced life support at point of injury and rapid helicopter evacuation to Level 2 Field Hospital (Role 3) capabilities is achieving the best survival ever in combat (1)! This is the main reason why the SAMHS moved from a single resuscitation approach at its Level 1 capability (3)(HYPERLINK \l "Sou08" 3), to an

integrated resuscitation and surgical concept, however, the *weapon system* to provide this is absent.

Timeliness remains one of the tactical yardsticks for providing operational health care. The timeline from wounding to surgical care remains one of the most challenging factors for the SAMHS. In Operation Iraqi Freedom, an increase in the timeline from 30 to 59 min between wounding and surgical intervention, resulted in an increase of 13,5% to 20,2% for those killed in action, but, more alarmingly, an increase from 0,8% to 5,5% in casualties who died of wounds (2). The American Special Forces classified 15% of those killed as potentially salvageable with adequate surgical intervention. Tai et al concluded that an absolute upper limit for formal commencement of damage control surgery is 120 min from wounding (4). This is the foundation of the SAMHS 1:2:4 doctrinal principle3). This requires that the SAMHS urgently addresses the deployable surgical capabilities in its arsenal – including damage control surgical capabilities and appropriately skilled manpower as far forward as possible.

We should learn from the present trauma experience in worldwide combat areas, where massive transfusion protocols are required (with blood unavailable in our deployments), deployed radiologist with capabilities has proven essential (FAST capabilities) and specialised nurses in deployed roles are used to provide required levels of care (1).

Irrespective of the *weapons* that may be available to operational medicine, the skilled human resource is, and remains, the warrior who will use these. This requires a very careful approach. The UK medical service emerged from the cold war over staffed, declaring components of their service and human resources redundant and reducing their manpower, only to experience critical shortages in human resources a scant four years later1). Civilian medicine remains the basis for clinical training between deployments and is the foundation for attracting appropriately skilled, motivated and committed civilian clinicians to serve in the Reserves. The proposals for Emergency Centres at military hospitals to breed these for battlefield utilisation will most certainly improve our capabilities.

Mental health capabilities are an integral part of the operational medicine arsenal and also require timely intervention to ensure survivability.

Reducing disease and non-battle injuries remains just as important. This includes comprehensive force health protection measures such as ensuring that adequate eye protection is provided and worn by all.

The Military Health Service should ensure that it counters the enemy's high technology weapon systems with similar if not better medical *weapons* to ensure optimal survivability of the wounded. This issue of MILMED *Scientific* aims at stimulating interest in operational medicine, not only inviting comment, but also providing advice on critical interventions that may be of value to counter enemy actions.

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OPERATIONAL MILITARY HEALTH SUPPORT PHILOSOPHY: A SOUTH AFRICAN PERSPECTIVE

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ABSTRACT

Human resources can be considered the most valuable resource of any military force. Health support is a key element in sustaining the physical, mental and social well-being of this resource and therefore vital to the success of operational readiness. Operational Health Support uses wartime and peacetime missions to direct the peacetime force preparation strategy and force employment for incidences of conflict.

Operational Health Support addresses the human battle space of a total onslaught against the human body, mind and relationships, rendering the individual incapable of effectively operating the weapon systems designed to win the land, air or maritime battles.

Within any battle scenario, it is important to analyse, through an appreciation, the enemy and its tactics, and to define the most appropriate composition of own forces, the operational battle design, the resources needed and the theatre of war.

Operational health support takes the responsibility for the casualty from point of injury until discharge or death, including the rendering of forensic services on the battlefield. This is delivered through a building block approach of stepped-up care to deliver a holistic health support system adhering to clinical and ethical principles.

INTRODUCTION

Human resources can be considered the most valuable resource of any military force. Health support is a key element in sustaining the physical, mental and social well-being of this resource and therefore vital to the success of operational readiness. A military health service organises, trains and equips to provide a health-ready fighting force capable of executing successful military operations. Together, a ready military health service and healthy, fit fighting forces ensure mission responsiveness.

MILITARY STRATEGY IMPERATIVES

The military strategy provides the answer to the military challenges that can be expected by the country in the future (1). The Employ Forces Strategy (which include the Force Employment Strategy, the Joint Force Preparation Strategy and the Multi-national Force Preparation Strategy), the Prepare Forces Strategy (including the Force Structure Strategy and the Force Preparation Strategy with ends, ways and means to prepare Combat Ready Higher Order User Systems), the Provide Forces Strategy (including the Acquisition and Research & Development Projects) and the Support Strategies further support the military strategy of the Republic of South Africa. These strategies shape the provision of operational military health support by the Military Health Service.

The Military Strategy identifies three military strategic objectives. These are to *enhance and maintain comprehensive defence capabilities*, to *promote peace,*

security and stability in the region and on the continent and *to support the people of South Africa*.

- To Enhance and Maintain Comprehensive Defence Capabilities. The approach to this military strategic objective is based on alliance and/or coalition warfare and multinational force employment. The Defence Force will, in cooperation with the neighbouring states, have a strategic defensive posture whilst maintaining sufficiently tailored operational and tactical offensive capabilities in order to deter potential threats. The concept of selective engagement will be applied to determine the Defence Force's scope and level of employment while early warning will be achieved through strategic positioning. The mission-trained force (multinational) will execute the operation. Special operations and activities can be utilised to protect foreign assets.
- To Promote Peace, Security and Stability in the Region and on the Continent. The promotion of peace, security and stability entails reaching out to Africa through the establishment of mutual trust and interests, acceptance of the concept of collective responsibility, multinational force preparation and planning, and the exchange of training teams, students and staff officers, information and technology to set the scene for a stable region. The RSA, as part of a multinational force and with support from the international community, will prepare itself for involvement in peace enforcement and/or intervention operations in order to protect regional interests.
- Supporting the People of South Africa. This military strategic objective entails supporting the population of South Africa by means of operations other than war during periods when the responsible state departments do not have the capacity to do so. The inherent capabilities of the Defence Force will be utilised to support other state departments in the execution of required tasks/operations. The concept of selective engagement will determine the level of involvement.

The way in which the Defence Force will achieve these three strategic objectives is

through a mission-based approach. This approach uses wartime and peacetime missions to direct the peacetime force preparation strategy and force employment for incidences of conflict. The following are two important concepts of the mission-based approach that will guide operational military health support:

- Selective Engagement. The concept of selective engagement indicates that the Defence Force will execute all the prescribed missions, but will be selective in terms of the extent to which operations and tasks emanating from these missions will be executed. This concept implies that calculated risks will have to be taken.
- Strategic Positioning. This concept indicates that the Defence Force is willing to proactively establish a sound security environment, supported by influencing political and military foreign relations actions, and the pre-placement of appropriate military capabilities.

The Military Strategy identifies the means to achieve these military strategic objectives as the following:

- Light Mobile Capability. Personnel and materiel must be prepared and sustained to participate in operations where agility, flexibility and limited firepower are required.
- Conventional Warfare Capability. Personnel, materiel and doctrine prepared and sustained to repel a conventional onslaught.
- Support Capability. The ability to support and sustain systems commensurate with the force and executing the mission according to the military strategic objectives ensuring strategic reach.
- C^4I^3RS. This is a collective description consisting of the elements of command and control, communications, computers, information, intelligence, infrastructure, reconnaissance and surveillance. It is the essential military sensory capability and command and control support for the whole range of military missions.

The Military Strategy guides the Military Health Service to be prepared to provide

operational military health support over the full spectrum of missions from conventional warfare to support to the people. This support must be flexible, agile and sustained and must be able to function in a multinational force environment and fit in with the C^4I^3RS capability of the supported force.

In multinational operations, specific national contingents may have a framework responsibility for the coordination of particular combat service support functions, or the provision of specific services or commodities for the whole force. It is thus essential that systems, units or forces be able to provide services to and accept services from other systems, units and forces and to use the services so exchanged in order to operate effectively together.

International law requires all casualties to be treated according to clinical priority regardless of origin. The medical plan will inevitably have a combined aspect as national contingents may provide different specialist medical capabilities or specific medical units. Casevac resources should always be integrated into a unified plan.

GENERAL APPROACH TO OPERATIONAL MILITARY HEALTH SUPPORT

This approach provides overall guidance to provide operational military health support and should be applied when planning military health support to any type of operation.

A Holistic Approach to Health

The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being. Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (2). In the military context, health may be defined as the ability of military personnel to function unimpeded by physical, psychological or social problems. In order to maintain and promote health, one should aim to alter the determinants. The health of a soldier is determined by a variety of factors, such as genetic, social, economic, environmental, lifestyle and operational factors, as well as access to health services. Due to the

nature of the military, soldiers are deliberately placed in danger with the knowledge that some are likely to succumb to disease, be injured or killed, or be subjected to circumstances that lead to family disruption. Although the Military Health Service is the primary military health care provider of the Defence Force, it is not solely responsible for ensuring a healthy soldier.

Responsibilities for Health

There are three broad areas of responsibility for health within the military: individuals, the chain of command and the Military Health Service.

- Individuals. Lifestyle and behaviour are a powerful influence on health. Military personnel therefore have considerable responsibility for their own health, which includes following preventative advice. All personnel should acknowledge these responsibilities and take them seriously. Personnel will require leadership, education and positive role models, particularly commanders, in order to increase awareness and individual responsibility.
- Chain of Command. The chain of command has control over a number of the determinants of health through its ability to influence occupational issues. The health of the military population should be an integral part of any human resources strategy, with measures to promote and maintain health enshrined in policy.
- The Military Health Service. The Military Health Service has two distinct areas of responsibility in contributing to military health: the provision of advice to the chain of command on the promotion of health, and the delivery of high-quality, timely health care capabilities in peace and war. Both make a valuable contribution to force protection. To ensure a healthy soldier, the Military Health Service applies a multidisciplinary approach that addresses the physical, psychological and social well-being of the soldier and his/her family.

The Human Battle Space

Within the land battle space, the air battle space and the maritime battle space it is of utmost importance for a soldier to focus on the task at hand. The enemy must not

only be out-fought but must also be out-thought. Cognitive dominance will be one of the most important attributes of the modern soldier to win the war and not only the battle. The relationship between a healthy body and a healthy mind is well known and therefore the military health service must strive to ensure optimal physical health as well as optimal mental health towards combat readiness.

It is true that we do not live in a perfect world and therefore there are a multitude of "enemies" with a total onslaught against the human body, mind and relationships, rendering the individual incapable of effectively operating the weapon systems designed to win the land, air or maritime battles in protecting the sovereignty of our country. Within this "human battle space", the enemy is as fierce and cunning as one would find in any other battle. The weapon systems to be employed are very sophisticated and can be very effective if optimally utilised. The battles are fought within the ecosystem we inhabit, within our population and society, within our immediate environment and within our own bodies.

Within the human battle space, the *enemy* has been identified as

- pathogenic organisms and their vectors;
- dangerous substances and the abuse thereof;
- uncontrolled and/or deliberate physical force. This includes the enemy threat leading to combat situations;
- harsh climatic conditions and other environmental hazards;
- diseases of life-style (the so-called non-communicable diseases); and
- malicious human behaviour and mental health.

Within the human battle space, the *own forces* have been identified as

- health care providers;
- stock and equipment;
- infrastructure;
- command and control;
- management information;

- support elements such as health intelligence, epidemiology and security; and
- appropriate research and development.

Within any battle scenario, it is important to analyse, through an appreciation, the enemy and its tactics, and to define the most appropriate composition of own forces, the operational battle design, the resources needed and the theatre of war. An appropriate plan must then be executed with dedication and determination. The human battlefield is superimposed onto every other battlefield and it can be stated categorically that, if the battles within the human battlefield are lost, the war will be lost.

Force Health Protection

Force health protection (FHP) is the military health strategy to support the military strategy. It starts at home and continues during every deployment scenario not only to ensure combat-ready forces, but also to ensure optimal operational health care support. The military force must have a robust resilience against the "*enemy*" within the human battlefield. Healthy and fit members are less likely to be injured, can withstand diseases and battle stress, and will heal much more quickly from wounds and other diseases.

Protection is built upon a strong partnership through the overarching partner process of Force Health Improvement, including a partnership between military and civilian health care professionals, line leadership and beneficiaries. It constitutes a cycle of assessment (continuous health surveillance), intervention (medical and other health-related interventions, disease and casualty prevention) and enhancement (health promotion).

Force Health Protection and Improvement include the following elements:

- Prevention activities like immunisations and vector control.
- Promotion activities like education and awareness.
- Occupational Health and Safety.
- Physical Training, Sport and Recreation.

- A healthy diet.
- Workplace programmes.
- Community health, including the following:
    - Food security.
    - Clean water.
    - Sanitation.
    - Environmental health.
    - Waste management.
    - Ecosystem interaction and preservation.
- Epidemiology and health intelligence.
- Health assessments.
- Risk management.

Operational Military Health Support

Operational Health Support is an integral part of the Force Health Protection process and is supported by Force Health Improvement measures.

The operational military health plan must provide for *preventative*, *promotional, diagnostics, curative, rehabilitative, palliative care and a research & development* approach during every operation regardless of the size, location and type of force or operation. This does not necessarily imply the physical deployment of elements to provide all these services in the theatre of operations. It implies that the process of ensuring health starts before a soldier becomes a casualty and continues until he or she exits from the system. Preventative programmes must be in place before, during and on completion of an operation to minimise casualties (both battle casualties and disease and non-battle injuries).

The operational health support takes the responsibility for the casualty from point of injury until discharge or death, including the rendering of forensic services on the battlefield.

The fact that deployments may be in remote areas should not have an effect on the quality of health care provided to the deployed soldier. Deployed members of a

Defence Force should, as a matter of principle, have the same quality of health care (or better) than what he/she would have received at the home base. The Military Health Service remains accountable for the provision of health support to members of the Defence Force and therefore will, as far as possible, plan to provide health support to own troops during Multi-National operations. In cases where this is not possible, planners should evaluate other nation support to ensure that the quality of service that is available is of an acceptable standard.

THE MISSION-TAILORED BUILDING BLOCK APPROACH

The size, duration and nature of deployments cannot be determined in advance. National security requirements may call for involvement in activities ranging from a major regional conflict to small, tailored health care teams operating in remote, very primitive conditions. Any deployment can grow (or shrink) within these upper and lower extremes.

Military health support must be flexible and modular and must anticipate changes in deployment requirements. The approach is to group a combination of operational military health building blocks according to the unique requirements of each mission. Each building block is designed as a specific functional capability (User System) to contribute to the holistic approach to military health support and can operate as an entity or as part of a bigger grouping.

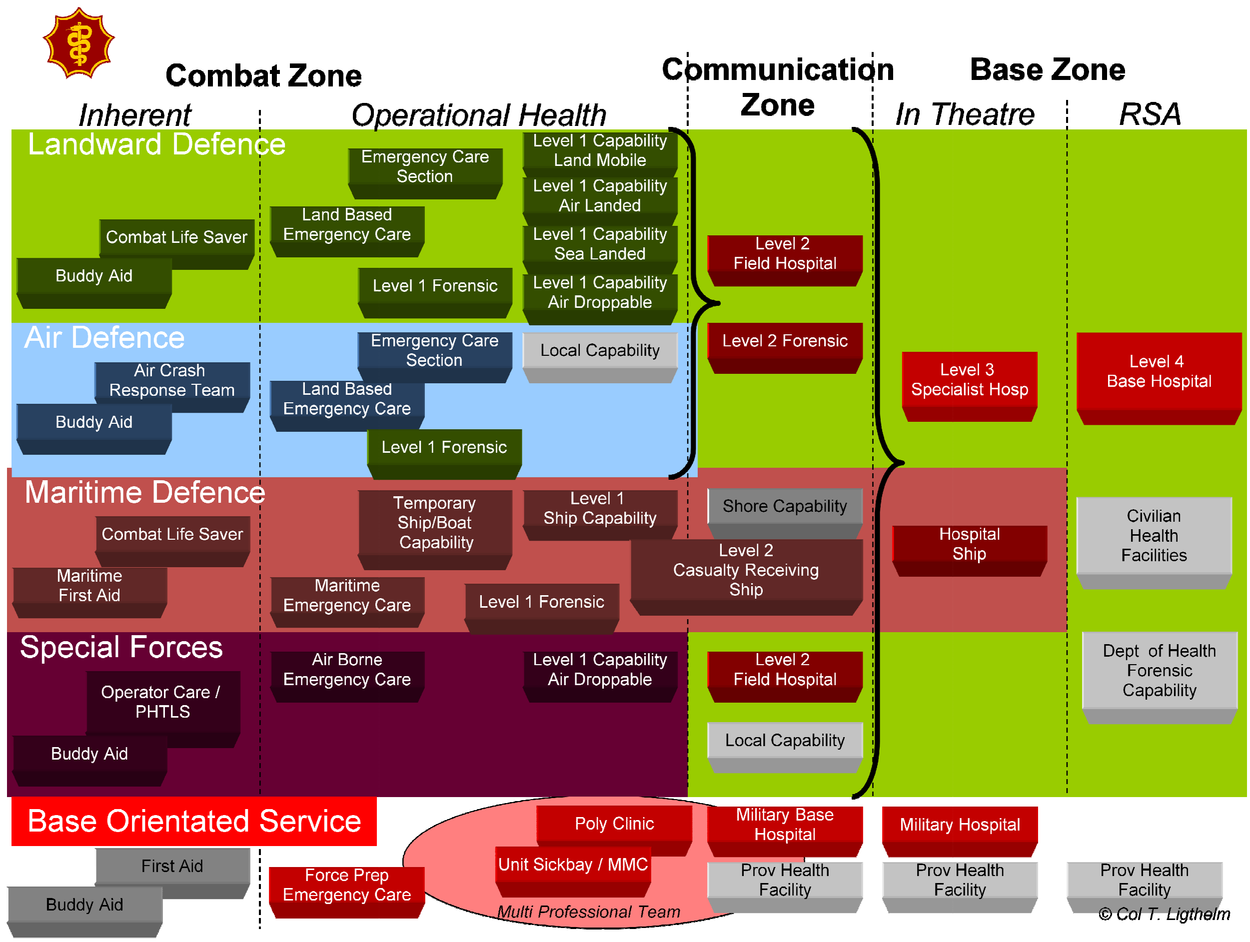

Figure 1: Stepped-Up Health Support Concept

The 1:2:4 Principle

In saving life, limb and organ (specifically vision), time is of the essence. It is essential that the "save life initiative" starts immediately after injury/illness. The grouping of casualties with the potential to benefit from medical intervention is the greatest in the first 30 minutes after wounding. 94% (ninety four percent) of deaths occur within the first two hours after injury (1). The longer the time-lapse between injury and surgery, the lesser the chance of success.

The approach should be to shorten the interval from injury to initial care, reducing the evacuation time to an appropriately capable health care facility for controlling catastrophic bleeding and managing the airway, breathing and circulation. This may often be achieved by bringing the care forward, rather than evacuating the casualty to the care. Time is therefore the guiding factor in determining where what capability

of support should be, while the number and type of casualties will determine the size and shape of each military health support capability.

The guiding rules to apply during the planning of operational military health support are as follows:

- Rapid access to first aid with battlefield advanced trauma life support standards of care within **one hour of wounding**.
- Access to surgical resuscitation (damage control surgery) for those who require it within **two hours of injury**.
- Definitive surgery within **four hours of injury**.

The Step-Up Approach

The Military Health Service subscribes to a step-up approach with the deployment of military health services based on the emergency care management capability of the military health support elements. Operational health support consists of six capability levels grouped in four lines of support The treatment capability of each level is intrinsic to the higher level, eg an advanced care facility will have the ability to carry out intermediate care functions. There is no requirement that a patient must necessarily pass through each echelon of care in progression during treatment and evacuation.

Operational Health Support Capability Levels

- First Responder. This comprises the buddy aid and combat-lifesaver capability and provides a lifesaving initiative by trained non-medical fellow soldiers from the combat element. This capability will be intrinsic to every operational element on section/team level.
- Emergency Care. This capability provides battlefield advanced resuscitation, stabilisation, evacuation of casualties and first line primary health care (treatment of minor ailments only) by trained operational emergency care personnel (OECPs and ECTs). It should be deployed with every operational deployment where the risk of casualties is medium

or higher and medical infrastructure is further than 10-30 minutes away.

- Intermediate Care. This is the first level where a medical officer and/or paramedic is available and provides an advanced trauma lifesaving capability, stabilisation, primary and secondary health care and evacuation to the next level. It should be deployed in situations further than 10-60 minutes from surgical infrastructure where the risk of casualties is high.
- Advanced Care. This capability provides emergency resuscitation and stabilisation, damage control surgery, second line health care, basic dental care, operational stress management, social work interventions, casualty evacuation to the next level and a preventative health service. This level of advanced support is normally deployed in cases where the appropriate level of care is not available within 2 hours after injury. If the situation requires, advanced care elements may be deployed forward with first line military health facilities.
- Specialised Care. This level includes specialist diagnostic resources, specialist surgical and medical capabilities, preventive medicine, ancillary health services, dentistry, psychology and social work. The holding capacity should be sufficient to allow diagnosis and inpatient treatment of those patients who can receive total treatment and be returned to duty within the evacuation policy laid down by the medical commander for the theatre of operations.
- Definitive Care. This level of care is usually highly specialised and time consuming. It would normally comprise specialist surgical and medical procedures, reconstruction, rehabilitation, convalescence, and psychological and social support. This capability provides definitive care of patients for whom the treatment required is longer than the theatre evacuation policy or for whom the capabilities usually found in the theatre of operations are inadequate. This level of care is provided by the military hospitals or a combination of military/provincial/private facilities in the RSA.

Lines of Operational Health Support. Lines of operational military health support are

identified in accordance with the echelon system and should not be confused with the levels of care. The lines of health support indicate the command level that controls the deployment.

- First Line Support. This line of support is found at the combat or combat support unit level and is responsible for the immediate support to such a unit. It includes the unit's integral first aid capability as well as the attached intermediate and/or emergency care capabilities.
- Second Line Support. This line of support consists of the advanced care capability and forms the second line of support for cases whose treatment requirement exceeds that of the first line capability. This level of care is normally controlled by the formation medical commander and is considered a formation asset.
- Third Line Support. The specialist care capability is the third line of operational military health support. It is normally deployed in situations where it is not possible to evacuate casualties requiring specialist diagnostic, surgical or medical services within the acceptable time restrictions to a suitable existing facility. It may also be deployed in situations where it will be more cost-effective to deploy a specialist capability to the theatre of operations than to evacuate casualties back to the military hospitals. The command affiliation of a third line military health facility will always be to the highest headquarters in the theatre of operations.
- Fourth Line Support (Home Base Support). This constitutes all those military and civilian health facilities permanently positioned in the RSA. It provides definitive care to those casualties who cannot be returned to duty within the theatre evacuation policy or who require treatment outside the capability of the in-theatre military health facilities.

PRINCIPLES OF OPERATIONAL MILITARY HEALTH SUPPORT

Timeliness

Timeliness concerns the provision of an in-time operational health support system

that provides appropriate health care at the right place with the right capability to ensure preservation of quality of life. This requires early warning and joint/multinational operational planning at all levels. Operational health care must ensure a timely step-up support system that adheres to the clinical principles to ensure preservation of quality of life. Health care facilities are located as far forward as possible; however, they must not be positioned so far forward as to interfere with combat operations or be subjected to enemy harassment.

Mobility

Mobility implies the ability to project operational health support capabilities by land, air and sea. This includes strategic, operational and tactical mobility. First line health care elements must maintain close contact with the manoeuvring combat elements they support. Therefore, they must have transportation (including evacuation capabilities) compatible with the combat units they support.

Flexibility

Flexibility involves the ability to adapt operational health support based on a detailed health appreciation in order to meet the health care requirements of a mission. The principle should be to deploy the appropriate health user systems and build them up according to a step-up approach.

Economy of Effort

Economy of effort concerns the concentration of available resources to provide a mission-orientated multidisciplinary capability to achieve optimal operational health care. This is achieved through a step-up building-block approach.

Multidisciplinary Approach

This approach implies the mission-driven utilisation of applicable elements of the multidisciplinary team as far forward as necessary within their scope of practice to ensure optimal operational health care.

Patient Safety and Security

Operational health support ensures optimal safety and security to the patient and his/her physical integrity and dignity. This is achieved through appropriate safety

measures, protection, professionalism and medical confidentiality and includes adherence to the Geneva Convention and Protocols, the Law on Armed Conflict, health ethics and statutory principles. The Military Health Service is dependant on the supported force to provide protection to its facilities, personnel and patients. Military Health Service planners should ensure that this aspect is addressed during planning and that the requirements are submitted to the Supported Force Commander in time.

Health Intelligence

Health intelligence is the continuous provision of a health intelligence capability that provides a health profile of the area of influence. This impact on the facilitation of the process of providing preventative health support supplemented by specific treatment protocols. It requires early warning and joint/multinational planning on all applicable levels.

Sustainment

An operational health support capability requires guaranteed logistical and personnel support that addresses the following critical aspects:

- A joint/multinational approach, including maintenance, repair and replacement of equipment and vehicles.
- Compatibility and interoperability.
- Focused logistics (balancing just-in-time with just-in-case).
- Personnel replacements.
- A focus on Military Health Service-unique and shared requirements.
- Thorough planning, constant liaison and close monitoring.

Unity of Command

The Military Health Service adheres to the principle of unified command. During joint operations, Military Health Service combat-ready force structure elements are placed under the operational command of the joint force commander for the duration of the operation. During multinational operations, Defence Force elements are placed under operational control of the force commander. Functional control is retained

within the Military Health Service. This implies that there will be a Military Health Service commander appointed for each Military Health Service force structure element to maintain functional control.

Conformity

The health service support plan must conform to the tactical plan of operations. It must also conform to the highest level of medical and other health-related care standards and ethics.

Continuity

Triage, treatment and evacuation must be continued until the patient reaches a health care facility capable of providing definitive care for his/her condition. No patient is evacuated further to the rear than is justified by the extent of the psychosocial and physical condition or warranted by the operational situation.

MILITARY HEALTH OPERATING SYSTEMS

Operational military health support is comprised of functional operating systems that provide a continuum of health care from the point of injury rearward to definitive and rehabilitative care in the sustaining base. It is impossible to address the total spectrum of systems within an article, therefore only the direct casualty care systems will be explained.

Medical Treatment System

In the forward areas of the operational area, health care personnel attached to the combat elements or a supporting medical element on an area support basis, provide first and second line medical treatment. Medical care at these levels includes emergency medical treatment, advanced trauma management, initial resuscitative surgery, life-and-limb-saving surgical interventions and routine sick reports.

Medical Regulating and the Patient Evacuation System

Medical regulating is the coordination and control of the movement of patients to the health care facility best suited to provide the required care. This function ensures the

efficient and safe movement of patients through the health care delivery system.

Patient evacuation provides the links between the lines of care on the battlefield. It provides continuous medical treatment while the patient is being evacuated rearward to the facility best suited to care for his/her health condition. Patient evacuation is accomplished by the lower role evacuating to the higher role. Evacuation encompasses the following:

- Collecting the wounded (which may include hot extraction of the wounded).
- Performing triage (sorting).
- Providing an evacuation mode.
- Providing medical care en route.
- Anticipating complications and being ready and capable to perform emergency medical intervention.
- Collecting and storing the bodies of those killed

Hospitalisation System

A hospitalisation system comprises medical treatment building blocks capable of providing inpatient care. It is appropriately staffed and equipped to provide diagnostic and therapeutic services, as well as the necessary supporting services required to perform its assigned mission and functions. In addition, a hospital may discharge the functions of an outpatient service.

Ancillary health disciplines form part of the hospitalisation system and have a definite role to play in providing operational military health support. Their support covers the total spectrum of care from prevention to rehabilitation. Ancillary health disciplines will generally not deploy lower than second line facilities. Ancillary health disciplines within the Military Health Service that will be deployed operationally include, but are not limited to, the following:

- Radiography.
- Physiotherapy.
- Dietetics.

- Medical technology.
- Biomedical technicians.

The various levels of hospitalisation include a Level 2 Field Hospital, Level 3 Specialist Hospital Capability (for example 2 and 3 Military Hospitals) and a Level 4 Base Hospital Capability (as example 1 Military Hospital).

Other Systems

Numerous other systems contribute to a holistic approach to operational support. These include a Preventative Health System to ensure a healthy soldier for deployment, Oral Health System addressing dental needs comprehensively and assisting in forensic identification of bodies, Animal Health Services addressing both the health of deployed animals and preventing zoonotic disease outbreaks, Psychological Support and Military Social Work Support ensuring mental and social resilience and addressing stress disorders, Military Health Forensic System collecting and transporting bodies including basic post-mortem investigations, Sustainment to enable systems to operate and ensuring projection of capabilities, Health Intelligence Support and a Patient Administration System ensuring accurate record keeping.

All of these systems combined represent a holistic operational health support system.

ETHICAL PRINCIPALS

The rendering of operational health support is guided by ethical principals directing action and guiding decisions.

The focus is to render effective operational health support to ensure that life is optimally preserved and health restored. Life is seen as a most valuable, irreplaceable status of the human being, therefore, soldiers are by International Standard Principles entitled to guaranteed, Operational Health Care available at all times.

This Operational Health Care will be delivered within ethical principals guiding the practitioner in his/her professional capacity. This includes that Health Care Practitioners will not use their medical knowledge contrary to the Laws of Humanity (2) (3) (4). They will deliver care for the sick and wounded without any adverse distinction founded on sex, race, nationality, religion, political opinion or any other similar criteria. Only medical urgency can justify priority in the order of treatment. In this role, a military health service will respect the need for emergency care to both own forces and other belligerents within the operational environment (2). At all times health care of at least the same quality that is available to own forces within the geographical borders of the country will be available to the deployed elements.

CONCLUSION

The Military Health Service Operational Support Philosophy forms the foundation for all operational military health support planning and guides the support to any operation in which soldiers may be involved.

The result of the application of this philosophy should be coordinated, cost-effective and sustained health support to operations in various operational theatres. It should ensure that casualties are returned fighting-fit to their units in the shortest possible time.

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Challenges in Estimating Battlefield Casualties

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ABSTRACT

Casualty estimates is the planning tool used by military health planners to determine the projected number of casualties expected during a specific military operation in order to determine what resources are required. It allows for the planning and deployment of the correct systems at the correct place, making sure that the right type of support is at the right place at the right time. It is, however, just as the words describe, an estimate and planning tool and should not be seen as a casualty prediction. In order to achieve this, one must be able to calculate the appropriate variables for the specific force levels and circumstances. The casualty estimate is the backbone of operational health planning, and should, therefore, be an embedded skill in all military health practitioners, especially planners. Casualty Estimation Tables are at the core of health planning and determine the ultimate risk to human life, implications which can and will be felt on tactical, operational as well as strategic levels.

The article gives an overview of the difficulty in compiling accurate and applicable casualty estimate tables and compares various models used by different countries. It highlights the problems of utilizing the present SANDF Casualty Estimate Tables and comes to the conclusion that the current tables are oversimplified and cannot address the specific needs of health planners or commanders. Not enough specifics and variables are available to everyone in the joint environment with little reference to the air component and little to no reference to the maritime component.

The article does not aim to provide alternatives for the present tables. The use and value of casualty estimates as the basic tool for medical planners are discussed and the article highlights the challenges in using the various models available. The need for future research to compile a valid South African model is underpinned by the findings.

INTRODUCTION

American Senator, John Glenn, said in 1997 that "it is easy to see. . . . People go off to war and the bands play and the flags fly. And it's not quite so easy when the flag is draped over a coffin coming back through Dover" (1).

That is the nature of the American public's sensitivity to military casualties. There is no intrinsic, uncritical casualty aversion among the American public that limits the use of United States (U.S.) armed forces. There is a wide range of policy objectives in terms of which the public is prepared to accept American casualties as the cost of success. Squeamishness about even a few casualties for all but the most important national causes is a myth. Nonetheless, it is a myth that persists as widely accepted conventional wisdom which seems to have translated to the rest of the world as well. Although a sensitive and emotional issue, casualties are, unfortunately, a reality of any form of military conflict. Determining the extent of this is most important on the operational level in the allocation of resources, the tactical level in the maintenance of combat efficiency and on the strategic level, especially for the politicians addressing strategic interests regarding foreign policy in sending sons and daughters of citizens to war

Military leaders adhere to the principle of economy of force and do not want to fritter away limited assets on missions that might detract from the ultimate mission of defeating vital threats to national security. It is with this in mind that casualty estimation is done in the military context to determine the projected number of casualties expected during a specific military operation. This is done not only to determine the required personnel to maintain force levels, but also to determine resource allocations and especially planning for health care by the Military Health Service. The planner, by carefully applying medical doctrine and principles, will strive to provide the best possible Health Service Support (HSS) system for all operations. Proper planning enhances the capability of the health units in providing effective HSS, which is a key factor in conserving combat power of the supported force (2).It forms the nucleus of medical planning for any type of operation whether it is armed conflict or peace support type operations- anywhere where health support of some sort is required.

WHAT IS CASUALTY ESTIMATION?

Casualty estimation is, as the words describe, an estimate. It is not to be seen as a casualty prediction. It will provide information to the commander of the operation or campaign allowing him/her to make an informed decision with regard to the risks pertaining to specific planned actions in relation to the number of estimated casualties. It further assists the health planner with valuable information on the estimated medical resources required to address the expected casualties. This is probably one of the most important aspects as it allows the medical commander to determine what resources are required to allow for the planning and deployment of the correct systems at the correct place, especially when using a “Building Block” health support system as is utilised within the SAMHS. This will ensure optimal utilisation of scarce resources.

Some of the data provided gives an indication of the anticipated number of casualties, the type and classification of injuries, hospital beds required, evacuation requirements in terms of numbers and expected flow, and, of course, the need for medical logistics including pharmaceuticals, blood and blood products, and more. It further serves as an indicator of resources required from other services, like aircraft for medical evacuation and special logistical requirements. This contributes to a more comprehensive sustainment requirement in the joint environment for the operational commander and staff to consider when planning a particular mission.

Casualty estimation is not an exact science but it attempts to include a vast number of factors to be analysed and considered to achieve a very realistic estimate. Although casualty estimation tables refer to exactly that, namely casualties, one often only thinks of the wounded or dead and tends to forget about the Disease and Non-Battle Injuries (DNBIs). Underestimation of aspects like acclimatisation, local health profiles, infrastructure and climate may cause an over-burdening of an already taxed HSS system. The importance of understanding the fluctuation in sick reporting levels during various stages of the campaign may have serious implications for force level maintenance. Disparities in figures calculated for various forces are also significant in the sense that generalised calculations for casualty estimates cannot be based on force levels alone.

The South African National Defence Force (SANDF), like other defence forces around the world, also utilises its own casualty estimation tables to perform the necessary tasks to ensure a comprehensive health support system in support of the intent and concept of operations of the operational commander. The validity and applicability of the currently utilised SANDF casualty estimation tables in the modern war theatres are questionable.

THE CURRENT SANDF CASUALTY ESTIMATION TABLES

The casualty estimation tables of the SANDF are vested in the Doctrine and earlier documents like the Operational Pamphlet of the South African Military Health Service (SAMHS)(3). The document originated as a result of the Border war in South West Africa (now Namibia) and Angolain which South Africa was involved .The casualty estimation tables utilised in South West Africaat the time of the conflict (1966 to 1989) were based on available figures utilised for the North Atlantic Treaty Organisation (NATO) forces. As casualty estimation tables are more often than not based on the rate of casualties experienced, it became apparent that the NATO tables did not address the type of warfare experienced by the South African troops and therefore it had to be adapted for the type of warfare experienced in Namibia.

The current doctrine allows for a more flexible approach in the deployment of medical resources to areas where the most casualties are expected, making sure that the right type of support is at the right place at the right time. In order to achieve this, one must be able to calculate the appropriate variables for the specific force levels and circumstances. The basis for calculation is still the NATO tables.

S/No	Command Level	BC Rate	BS Rate	Total BC Rate
	a	b	c	d
01	Battalion	20.5%	4.1%	24.6%
02	Brigade	6.9%	1.4%	8.3%
03	Division	3.0%	0.6%	3.6%
04	Corps	1.4%	0.3%	1.7%
05	Army	1.0%	0.2%	1.2%

Table 1: The Planning Statistical Data (4)

Total Battle Casualty (TBC) rates include the Killed-in-Action (KIA), Captured and Missing-in Action (MIA) and Battle Stress / Battle Shock (BS) cases.

S/No	Aspect	Abbreviation	Percentage of TBC
	a	b	c
01	Killed-in-Action	KIA	17%
02	Captured/Missing-in-Action	CMIA	8%
03	Wounded-in–Action	WIA	58%
04	Battle Stress Cases	BS	17%

Table 2: The different categories (4)

The NATO casualty estimation tables provide a general picture for various force levels ranging from battalion to an army size and provides a general idea of casualties expected ,especially from the perspective of the operational-level commander. No specifics with regard to activities, smaller groupings in support of the focus of main effort or tactical considerations are included in detail. This may prove sufficient to a degree at the military strategic and operational levels of war, but lower down, especially for health care, these are inadequate especially looking at DNBIs again.

UTILISING THE CURRENT TABLES FOR CALCULATION

A recent attempt at the SA National War College (SANWC) to create an electronic instrument (MS Excel-Based) to assist in calculating casualties during campaign planning proved more difficult than anticipated. Current tables are oversimplified and cannot address the specific needs of health planners or commanders. Not enough specifics and variables are available to everyone in the joint environment, with little reference to the air component and little to no reference to the maritime component. This will require future research to rectify the shortcomings.
These aspects are further exacerbated when functioning in the joint and multi-national environment. The result of utilising generic tables may lead to very high numbers being estimated, and therefore the commander tends to underplay the value of this instrument.

The casualty estimate is the backbone of operational health planning, and should

therefore be an embedded skill in all military health practitioners, especially planners. This no longer seems to be the case. Furthermore, the current tables, although practical, may be outdated and require further development and refinement based on real-time information and statistical data.

COMPARISON WITH OTHER COUNTRIES

The British Military indicates that specific Casualty Estimation would only be done if the specific threat is known. They refer in their doctrine to Generic and Operationally Specific Estimates (5). Generic Estimates are used in the absence of a specific threat whereby the generic rates, such as those published by NATO, are still utilised. Operationally Specific Estimates, on the other hand, are used when a particular threat is identified. This allows for detailed planning and resource allocation. The main steps in estimating both are the same.

Firstly, it determines the Population at Risk (PAR).

Secondly, the Casualty Rate is estimated on a pro rata basis across the PAR expressed as a rate over time, or as the total numbers of casualties expected for particular engagements.

Thirdly, the Casualty Profile is calculated as a relative proportion of different casualty types.

Lastly, the Casualty Flow refers to when casualties are expected and the gaps between these periods.

In the Allied Joint Medical Support Doctrine as used by the US (6), it is also reconfirmed that casualty estimates are the core of medical plans. In any scenario, the analysis of likely casualty rates and numbers has a great political and operational significance and is fundamental to establishing the medical support requirements. It is a prediction of total personnel losses in an operation due to various causes expressed in numbers per day.
The various casualties are also broken down into Battle Casualties (BC) and Non-Battle Casualties (NBC).

BC includes Killed, Captured and Missing-in-Action (KCMIA), Wounded-in-Action (WIA) and cases of Battle Stress (BS). Non-Battle Casualties include Disease and Non-Battle Injuries (DNBIs). It further describes the casualty rate as a daily rate (number of casualties/1000 men/day).

Although the SANDF tables are similar to the NATO approach, as well as the nations mentioned, the big difference is the fact that more detail is considered if the particular threat is known. A lot more emphasis is placed on the importance of DNBIs as well as the Theatre of Operation (TOO) where the conflict is taking place. Therefore, note the importance of realising and addressing the various health profiles, not only of the country in which the conflict is taking place, but also that of the Troop Contributing Nations.

In comparing the various policy documents utilised by the United Kingdom, NATO, the USA, as well as the RSA for determining casualty estimates, one cannot help but realise that the fundamental elements are similar in terms of the variables considered in the calculation. Although the fundamental ideas are similar, there are still some differences- the biggest of which is the extent to which the various factors can be adapted and interpreted. The Army Casualty Estimator (used by the USA) allows for many more options within a specific element than any of the other doctrines.

However, what is very important in these comparisons, is that the elements that are utilised are all applicable to the commander's battle design and, therefore, it again stresses the importance of joint planning with the medical staff being up to date with the requirements and vision of the commander to determine realistic casualty estimates.

A second very important aspect of the U.S. doctrine includes matters such as Fauna and Flora, disease, displaced persons and local resources, which again underlines the importance of Health Intelligence in determining the art of the possible.

The third aspect is the ease of working with the computerised casualty estimation tool which provides realistic casualty estimation based on the applicable data. This makes the calculation easier and quicker, but also more trustworthy than a generic percentage coupled to specific force levels. The biggest drawback of the particular tool is the fact that

it is basically limited to the tactical level and does not allow for a quick calculation of overall casualty figures on the operational level.

CHANGING NATURE OF WARFARE

The Gulf War of 1991 stands out from other conflicts experienced in the 20th Century iro the low number of casualties experienced by the Coalition and Iraqi forces. In total, more than a million military personnel from both sideswere involved. On the Coalition side, the United States lost 147 Killed-in-Action (KIA), Britain lost 24 and Saudi Arabia 29(7).
It is relatively easy to determine the casualties post conflict as it is a mere case of calculation. With different systems being utilised by various countries, calculating the injured proofs to be more complex. General consensus is however that around 450 soldiers of the United States were injured, with a similar number from the rest of the coalition.

It is important to note that other causes of death and serious injury amounted to 1500 for the United States. British Forces that lost only 24 members KIA had to return 700 of their personnel home due to illness or accidents. The current tables focus on Battle Casualties but underplay DNBIs. The Operational Commander must utilise such calculations to ensure mission success. In the case of the Gulf War, penetrating deep into Iraq and planning to stay a long time, casualty estimates were at the heart of the planning. The commander would select a combat plan shaped by these assessments, but still the actual number of casualties could not be predicted.

The military today is being tasked with broader security missions. It is expected to tackle challenges ranging from peacekeeping to the proliferation of weapons of mass destruction. Providing humanitarian aid, combating terrorism, and confronting international drug cartels and organized crime are among the support duties. This means that troop requirements will not change significantly. The Armed Forces will continue to need substantial numbers and tactical leaders with the motivation, skills, and mental agility to operate decisively in a complex, confusing, and dangerous international arena.

As one can imagine, these operations bring their own dimensions and challenges and this is equally true in terms of the estimation and prediction of casualties. Although these

operations may in some sense be referred to as Military Operations Other Than War (MOOTW), they are not the focus of the current casualty estimation tables.

War in its full essence is not a thing of the past, but there seems to be a shift in the conventional role of the Military of tomorrow towards MOOTW. On the strategic and political level it would mean lower body counts in exercising foreign policy and would be more acceptable to the public at large. The operational level commander and staff will be confronted with fewer resources and financial backing than during war but may be required to perform an array of tasks within the scope of this limited resource pool. For the health planner, it would mean fewer battle casualties and more DNBIs- a significant mind shift. The changing environment of the complex emergencies in which the militaries of the world find themselves demands that proper planning for all contingencies must be done effectively to ensure that the military can function in an efficient and cost-effective way.

CONCLUSION

Casualty estimates are and will remain major resource drivers and, although an inexact science, accuracy is important. The existing casualty estimation tables in use in the SANDF may not address the level of accuracy that is required, especially in the current battle space. The environment in which the militaries of the world find themselves is changing so rapidly iro the role and complexity of modern conflicts that the Military must adapt constantly so as not to be caught unawares. The SANDF, and the SAMHSin particular, cannot be reactive in trying to address the important aspects of comprehensive health care on the battlefield. Central to this is proper planning of resources required to maintain force levels. With proper planning, poor performance is prevented. Casualty Estimation Tables are at the core of health planning and determine the ultimate risk to human life, the implications of which can and will be felt on tactical, operational as well as strategic levels. It is therefore important that they must be contemporary, realistic and practical to ensure that the commander has the correct risk indication and that the soldier receives the health care which he or she deserves on the battlefield.

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Triage in the Combat Scenario as a Tool for the Optimal Treatment and Evacuation of the Wounded Soldier

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ABSTRACT

Deciding which patient to treat first when more than one patient requires medical treatment is a decision that must be made on scientific grounds. The use of evidence-based triage protocols could significantly help medical personnel in making the decision.

Patients are prioritised into categories according to the life or limb threatening level of their injuries. The higher the category, the more severe the injuries and the more urgent the medical treatment required.

Triage SIEVE is a model based on the mobility and ABC (Airway, Breathing and Circulation) presentation of the patient. This model is used to perform initial / primary triage and is presented in an easy-to-follow algorithm.

Triage SORT takes into consideration anatomical and physiological parameters of the patient. Clinical knowledge and experience are important in the interpretation of the patient's presenting signs and symptoms in order to make a decision.

On the battlefield, reversed triage may be used. In this scenario, the patients with minor injuries are treated before patients with more serious injuries in order to return them to the battlefield.

INTRODUCTION

Triage was initially developed by Dominique Jean Larrey (1,5), a surgeon during the Napoleonic Wars (1803-1815). He realised that casualties must be sorted into priorities of care to optimise care without taking their military rank into consideration. His objective was however to treat the less injured first to get them back to battle as soon as possible.

Triage existed in the past but only informally. It was only during World War I (5) (1914 – 1918)that formalised triage was initiated by French doctors who were treating the wounded on the battlefield as well as at the aid stations behind the front.

Until recently, triage was frequently performed as a matter of “the best guess” based on the experience and perception of the triage officer as opposed to a meaningful assessment based on repeatable criteria.

In the past, victims of war or casualties were prioritised according to three basic categories:

- Those who are likely to live, irrespective of what care they are going to receive
- Those that are likely to die, irrespective of what care they are going to receive
- Those for which immediate care might have a positive outcome

The modern-day approach in triage of casualties has become more scientific, based on scientific criteria and repeatable by different triage officers. Patients are now classified according to the following categories (4,5):

P1: Critical: Those in need of immediate life-saving treatment.
P2: Urgent: Those in need of medical treatment that can be delayed for a limited time period.
P3: Minor: Those in need of minor medical treatment.
P4 (P1 Hold): Patients not salvageable with the resources available or who are so severely injured that they cannot be saved.

Dead: A patient that is dead. As there is no priority coupled to the management of the dead, corpses are not allocated a priority.

During the primary or initial triage, the clinical interpretation and the knowledge of the specific signs and symptoms of the wounded soldier's injuries are not needed (5). Initial or primary triage is thus based on an easy-to-follow algorithm. Due to the simple nature of the algorithm, non-clinical staff (eg pharmacists, social workers, and psychologists) can be used at this level as triage officers. This will leave trained and skilled medical staff (Operational Emergency Care Practitioners, Nursing Officers and Medical Officers) free to initiate treatment of the wounded soldier.

Secondary triage is more scientific and clinical knowledge-based (5). Specific signs and symptoms are taken into account in the assignment of a specific triage priority. Personnel that perform secondary triage thus require clinical training and experience.

The aim of triage is to ensure the *greatest good* (care) for the *greatest number* of casualties to ensure the optimal utilisation of medical personnel, equipment, and facilities (4,5).

TRIAGE PRIORITIES

Within the South African Military Health Service, as in the Emergency Medical Services three standard triage priorities are distinguished with a possible forth grouping used in exceptional circumstances.

Priority 1 - Critical

Patients classified as Priority 1 (P1) require immediate interventions or even surgery in order for their life or limb to be saved. To put it more simply, if the patient does not receive immediate medical attention, the patient will die. The key to successful triage is to identify these individuals as quickly as possible. Examples of patients in this category include, but are not limited to, haemodinamically unstable patients with airway obstruction, chest or abdominal injuries, massive external bleeding, or shock (4). As a planning norm, this grouping on average represents 10% of the live casualties in battle or in a major incident. If a colour coding system is used, this category is marked RED.

Priority 2 - Serious

Patients classified as Priority 2 (P2) are injured in such a way that they might require surgery or constant medical attention. The patient's general condition, however, permits that if surgery is needed; it may be delayed for a couple of hours. Examples of injuries that would be as signed to a P2 category include, but are not limited to, large tissue wounds, fractures to the major bones, intra-abdominal or thoracic wounds or burns to less than 20% of the body surface area. Medical treatment such as splinting and pain control will be required (4). On average this priority represents 15% of the surviving casualties. In a colour coding system, this category is marked YELLOW or ORANGE.

Priority 3 – Non-Urgent or Minor

Patients classified as Priority 3 (P3) have minor injuries, the so-called walking-wounded. They do not require immediate life saving medical interventions. When colours are used to indicate the classification, P3 is indicated by GREEN. Examples of patients in this category include, but are not limited to, small burns, lacerations, abrasions and small fractures(4).This priority is on average the largest group of casualties and represents 75% of the surviving casualties[1].

Priority 4 (or P1 HOLD)

Patients classified as Priority 4 (P4)are so severely injured or moribund that their chance of survival is almost non–existent, given the resources available for their treatment (4,5).In some triage systems, the terms **P1 Hold** or **expectant** are used to identify this category of patients.

The P4 priority is the casualty who would have been a P1 priority, if there were adequate resources available. However, with the P4 priority, the treatment of the patient cannot be initiated with the resources available at that moment in time.

The P4 priority is activated to do "the greatest good for the greatest number of patients" taking into account the limited resources available. If more resources become available, any surviving P4 patients are immediately re-triaged to P1 for immediate care (6).

[1] It is emphasised that the distribution of 10% Priority 1, 15% Priority 2 and Priority 3 75% are planning norms based on analysis of battlefield statistics.

Patients in this priority must still be provided with comforting measures and pain medication and must be treated with the necessary respect (4).

TRIAGE SIEVE

The Triage Sieve method (Diagram 1) can also be referred to as primary or initial triage (5). Triage Sieve is used as an initial tool for the fast and simple prioritising of a large number of casualties simultaneously.

Triage Sieve is a quick “first look” triage to prioritise the many casualties for care. Clinical interpretation on how the patient’s condition may change must not be taken into consideration. As the Sieve method is a simple procedural method of triage, the use of non-clinical personnel to perform Triage Sieve may be considered during this phase to optimally use clinical personnel to provide emergency interventions and execute more advance triage procedures.

Triage Sieve is based on two fundamental principles: Mobility and the ABC (Airway, Breathing and Circulation).

Mobility:
The first step is determining the mobility of the patient. Patients that can still walk are prioritised as P3. It does not matter if the patient has a laceration, fracture, or any other injury. As long as the casualty is able to move/walk on his/her own he/she is prioritised as a P3 patient. The patient is immediately directed to the P3 treatment area.

Should the patient be seriously injured, but able to walk he/she is still triaged as P3 at this stage and is directed to the P3 treatment area where skilled medical staff evaluates every patient using secondary triage methods.

Airway and Breathing:

The second step is to determine whether the casualty is breathing. If the casualty is not breathing, the airway is opened with simple airway manoeuvres such as chin-lift or jaw-thrust and breathing effort re-assessed. If breathing is absent, the patient is considered to be dead[2].

If breathing is detected once the airway is opened, the patient is prioritised as P1 - *airway problem.* This patient is immediately transferred to the P1 resuscitation area*.*

For casualties who were breathing, the respiratory rate is used as a tool to determine effectiveness of ventilation. If the respiratory rate is **below 9** or **above 30,** the casualty is prioritised as P1- *breathing problem.* This patient is immediately transferred to the P1 resuscitation area*.*

If the breathing rate is **between 10 and 29**, continue to the next step on the Triage Sieve algorithm assessing circulation.

Circulation:

The third step is to do an assessment of the circulatory status of the patient. Circulation is assessed by means of the pulse rate (radial). If the pulse rate is **above 120,** the casualty is prioritised as P1 - *circulatory problem.* This patient is immediately transferred to the P1 resuscitation area*.*

Capillary Refill Time (CRT) can also be used as an indicator of the circulatory status, however, evaluating capillary refill time might be difficult in the combat scenario due to austere conditions. In the dark, sufficient light is needed to accurately assess capillary refill time. Switching on a light in the dark, austere battlefield environment will make the medical personnel immediate targets. Cold conditions and subsequent hypothermia also make CRT an unreliable indicator. Assessing CRT needs to be used with caution. . If the capillary refill time is longer than 2 seconds, the casualty is prioritised as P1 – circulatory problem.

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[2] It must be emphasised that Triage Sieve is used in the Major Incident or disaster situation where a large number of patients need to be assessed and prioritised in the shortest possible time. It is within this environment that the patient with an open airway that is not breathing is classified as dead. If more resources are available, the more advance Triage Sorting tool may be utilised.

P2 ALLOCATION

If all of the abovementioned criteria are within the normal limits of the algorithm, the casualty must be prioritised as a P2 priority and transferred to the P2 treatment area. P2 patients therefore have a pulse rate of less than 120 beats per minute or a capillary refill time of less than 2 seconds.

TRIAGE SORT

Triage Sort (Diagram 2) is performed as the secondary triage (5). Triage SORT is thus performed when more resources, time and skilled personnel are available, such as at the stabilisation point, the Level 1 Resuscitation Post and at the Level 2 Field Hospital. Often, when a large group of patients arrive simultaneously, they are first triaged using the sieve method to get them into specific categories, then every category is revisited and the casualties re-evaluated using the more refined Triage Sort method.

Diagnostic equipment (blood pressure monitors) must be available to aid in assigning triage priorities.

Triage Sort is a physiological measure of the severity of the casualty's injuries based on the following three parameters: Glasgow Coma Score, Respiratory rate and Systolic Blood Pressure.

Step 1: Determine the Glasgow Coma Score of the casualty.

Step 2: Determine the Systolic Blood pressure of the casualty.

Step 3: Determine the Respiratory rate of the casualty and convert the respiratory rate to a value using the scale provided.

Step 4: Assign a score according to the measured value for each physiological variable.

S No	Physiological Variables	Measured Value	Score
	A	**b**	**C**
1	*Glasgow Coma Score*	3	0
		4-5	1
		6-8	2
		9-12	3
		13-15	4
2	Systolic Blood Pressure	0	0
		<49	1
		50-75	2
		76-89	3
		>90	4
3	Respiratory Rate	0	0
		1-5	1
		6-9	2
		>30	3
		10-30	4

Table 1: Measured Values and Scores of Physiological Variables

Step 5: Add up the allocated scores: Glasgow Coma Scale + Systolic Blood pressure + Respiratory Rate. (Note the original Glasgow Coma Score total is not added in but only the converted score is used)

Step 6: Determine the triage priority according to the accumulative score.

S No	Score	Triage Priority
	A	B
1	1-10	Priority 1
2	11	Priority 2
3	12	Priority 3
4	1-3	Priority P1 Hold/ P4
5	0	Dead

Table 2: Triage Sort – Score and Triage Priority

Step 7: Take into account anatomical and physiological aspects that may have an effect on the nature of the injury. The Triage Officer may use clinical judgement and assign a higher triage priority to the patient based on specific findings indicating the need for more urgent treatment of the patient. It must be emphasised that the use of clinical judgement to upgrade a patient's triage priority must be based on observed findings and not on possible deterioration of the patient's condition. For example, a walking casualty with facial burns may be heamodynamically stable and based on clinical findings be categorised as a Priority 3 casualty, however, due to clear facial burns, singed facial hair and soot on the tongue, the patient requires intervention to maintain an airway and is therefore upgraded to a Priority 1 - airway patient.

This action must, however, be used with great caution to prevent large numbers of casualties being upgraded to Priority 1 based on assumed possible complications and cluttering the emergency treatment capability.

TRIAGE IN THE OPERATIONAL SCENARIO

The choice of which triage system to use in the operational scenario will depend on the location and resources available (1).

On the battlefield, triage takes place within an area with already limited resources. Triage determines if casualties should receive immediate treatment, eg application of a tourniquet

to stop catastrophic bleeding, or whether transfer to the stabilisation point is possible. In this situation, Triage Sieve will be applied continuously and repeated at each point in the evacuation chain until the casualty reaches an area where a more refined triage method can be used. This is often only possible when the casualty reaches the Level 1 Resuscitation Post.

Basic principles that can aid in the triage process on the tactical battlefield environment are (4):

1. Movement of the casualty and attendant out of danger take precedence over a life saving procedure or other medical interventions. Casualties who are not clearly dead may be moved to cover, if possible, and/ or on command of protection forces.

2. Perform an initial rapid assessment of the casualty as soon as cover is reached. This assessment should not take longer than 60 seconds (1 minute) per casualty and includes Triage Sieve.

3. Treat any life-threatening haemorrhages and perform life-saving interventions as needed. For example, to open airways, stop bleeding and stabilize injured limbs will save lives and reduce further injuries. Pressure dressings and tourniquets are very useful tools to prevent catastrophic bleeding, which is a major cause of deaths on the battlefield.

Please take note that these principles apply to the combat scenario where there are limited resources. Care under fire poses a lot of challenges to the medical personnel, especially with haemorrhage control that takes priority.

Initiating the *Priority 4 (P1 HOLD or expectant) category* can be forced by the tactical situation. It is thus advisable to obtain sanction from the higher headquarters (HQ) to initiate the Priority 4 category at the Level 1 Resuscitation facility. The higher HQ is more aware of the complete tactical situation at hand and the possibility of receiving more resources. If more resources become available or, due to the tactical situation, no more patients will be arriving at the specific facility, all currently available resources can be used for the treatment of the patient. If, however, the higher head quarters are aware of a hostile action taking place with resulting large numbers of casualties, it may advise that the Priority

4 category is used to free-up resources for additional casualties that are on the way. It must be emphasised that the decision to activate the Priority 4 category is seldom taken and must be based on a proper tactical appreciation of demand versus resources.

The United States of America Marine Corps describe the principles of tactical / battlefield triage as follows (5):

1) To accomplish the greatest good for the greatest number of casualties.
2) To employ the most efficient use of available resources.
3) To return personnel to duty as soon as possible (Reverse Triage).

REVERSE TRIAGE

In some situations the preservation of fighting power may be of utmost importance for the survival of the element. In these instances it might be necessary to treat less seriously wounded or injured before the severely wounded or injured casualties to get them back fighting. As the less injured are treated to the level that they can return to the fighting, efforts can then be redirected to the seriously wounded that will require all available resources to be treated. This concept is called reverse triage where Priority 3 casualties are treated/stabilise first to get them back fighting, then try to save the priority 1 and 2 casualties.

in certain scenarios, it might be of the utmost importance to direct the medical resources first towards the injured medical personnel as this may be advantageous to ensure that they survive to continue with the treatment of the injured soldiers / casualties.

Triage is not a democratic decision-making process and requires very tough decisions in a very short time. The “return to battle” or a “fight to save the ship” is a tactical scenario that may take precedence over “best medical care practice” (1,2). The decision to initiate reverse triage can thus be forced by the tactical situation and not only by the clinical decision making process.

RE-TRIAGE

Triage is never a one-off process. It is repeated continuously at every link of the evacuation process and after each intervention. At arrival on the scene of a Ratel vehicle that was shot out by enemy fire, that has been declared safe by the fighting element, the medic will assess all casualties using Triage Sieve and allocate priorities. The team will then use these priorities to extricate the casualties from the vehicle to a stabilisation point. At the stabilisation point all casualties are re-triaged using Triage Sieve to determine their present condition to determine the need for intervention. After interventions, for example, inserting a naso-pharyngeal airway and applying a bomb bandage, the casualty is re-triaged as his/her condition may now be more stable. This process is repeated continuously.

EVACUATION

Two key factors must be considered in making a decision on the evacuation of a casualty to a higher level of care, namely the current triage priority and the required treatment(5). These two factors are used to triage the casualties for evacuation.

Triage Priority

As indicated above, the patient must be re-triaged after receiving any form of treatment. Additional criteria must then be added to determine the evacuation priority. The triage priority alone may not be the sole determination for evacuation priority. The availability, type and capacity of vehicles are examples of additional criteria that must be kept in mind and added during the decision making process regarding the patient's evacuation priority. If, for example, after initial treatment the patient is re-triaged and his/her priority has changed from P2 to P3, a sophisticated means of transport is not needed and his/her need for immediate transport to a higher facility is less urgent. The first available mode of transport may not be the appropriate mode for the specific casualty and the team may decide to evacuate the priority 2 casualties with the available ambulance and hold the priority 1 casualty back for the helicopter confirmed to be landing within a few minutes' time. The most appropriate means of evacuation must be used to ensure that each patient reaches the next level of care alive.

Treatment

The correct amount of treatment is necessary to ensure that the patient survives to the next level of care. According to the patient's priority classification, treatment and packaging must be restricted to what is necessary for safe and effective evacuation. An unstable casualty results in an unstable evacuation. It may be indicated to hold back a higher priority to complete preliminary stabilisation while a lower priority casualty is evacuated first.

Often the team is confronted with two or more casualties with the same triage priority, but only space to evacuate one casualty. In this type of situation, the criteria of who will benefit the most by the treatment at the next level of care must be considered as additional criteria to determine evacuation priority.

Evacuation triage, therefore, not only uses Triage Sieve or Sort, but also considers the additional criteria of treatment requirement to determine the evacuation priority.

CONCLUSION

Casualties must be triaged at every link of the evacuation process (chain) as triage is a dynamic process and the casualty's condition can deteriorate at any time, or improve after received treatment.

Triage in the tactical situation is an art that requires situational awareness, decisiveness and clinical expertise. Each decision is driven by factors such as the personnel versus the casualty ratios, provider skills, accessibility of equipment, and the availability of evacuation, communication and supplies. Time, distance and weather may also play significant roles as do fatigue, confusion and panic(1). Triage Sieve provides the tool for scientific triage at this level. This can be done by any person available on scene.

As soon as a casualty reaches more appropriate levels of care where more resources are available, a more detailed triage process can be used. Triage Sort provides the tool for this assessment, but requires clinical knowledge, equipment, time and capability to calculate scores. It is recommended that it is used from the Level 1 Resuscitation Post to the Level 3 Specialist Hospital.

The category of Priority 4 is a very specific category reserved for very specific situations where the need totally overwhelms the available resources and it is very seldom activated.

Reverse Triage refers to a unique system to optimise treatment to preserve fighting power in a desperate battlefield situation.

Evacuation Triage uses the same system but additional criteria are taken into account.

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Triage SIEVE

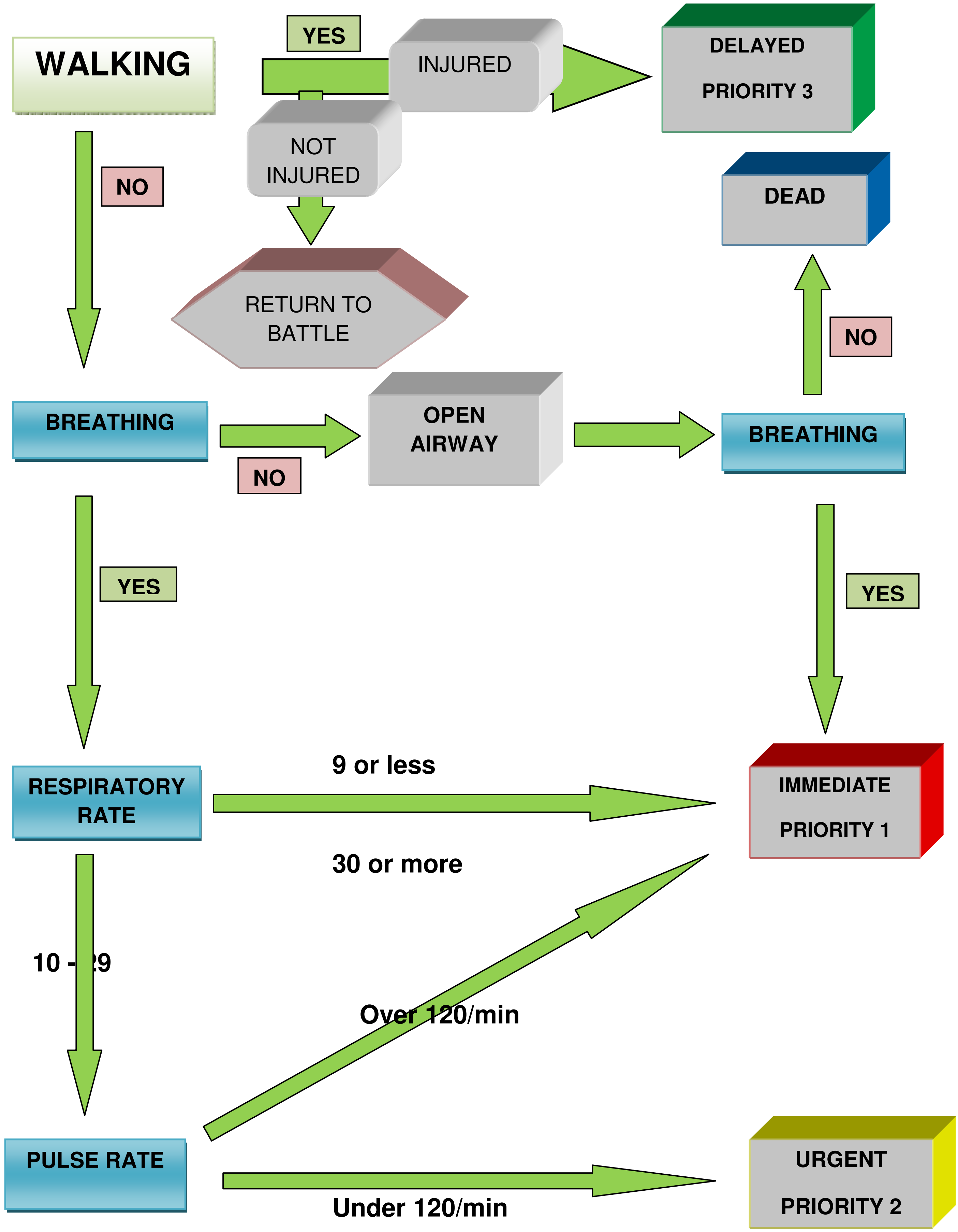

Diagram 1: Triage SIEVE

Triage SORT

Step 1: Determine the Glasgow Coma Score (GCS) of the casualty

A: Eye Opening		B: Verbal Response		C: Motor Response	
Spontaneous	4	**Orientated**	5	**Obeys commands**	6
To voice	3	**Confused**	4	**Localises**	5
To pain	2	**Inappropriate**	3	**Pain withdraws**	4
None	1	**Incomprehensible**	2	**Pain flexes**	3
		No response	1	**Pain extends**	2
				No response	1

Step 2: Determine Systolic BP

Step 3: Determine Respiratory Rate

Step 4: Assign a score according to the measured value of each variable

Systolic BP	Score	Respiratory Rate	Score	GCS	Score
>90	4	10 – 30	4	13 – 15	4
76 – 89	3	>30	3	9 – 12	3
50 – 75	2	6 – 9	2	6 – 8	2
1 – 49	1	1 – 5	1	4 – 5	1
0	0	0	0	3	0

Step 5: Add up the allocated scores

Systolic BP + Respiratory Rate + Glasgow Coma Score
= Accumulative Score

Step 6: Determine the Triage Priority according to the accumulative score

Accumulative Score	Triage Priority
1 – 10	**Priority 1**
11	**Priority 2**
12	**Priority 3**
1 – 3	**PriorityP4 (P1 Hold)**
0	**Dead**

Step 7: Take into account any anatomical or physiological aspects that may have an effect on the nature of the injury. Triage Officer may assign a higher triage priority.

Diagram 2: Triage Sort

Airway Management in the Military Environment

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ABSTRACT

Obtaining and maintaining the airway in the battlefield casualty can make the difference between life and death. The article explains the management of the airway in a casualty beginning with basic manoeuvres and equipment all the way to the advanced airway with alternative devices, supraglottic devices and the surgical airway. The specific management of the airway in the challenging conditions of the battlefield is discussed under the different phases encountered on the battlefield.

INTRODUCTION

Airway management is the "A" in the ABCDE algorithm primarily used by all emergency medical personnel in any critically ill casualty. Failure to maintain oxygenation and ventilation in a casualty will lead to secondary brain injury and even death. Adequate airway management and ventilation which provide sufficient oxygen delivery to all parts of the body and especially to the brain are the most important components of critically ill or injured casualty care.

BASIC AIRWAY MANAGEMENT

Recognition of airway compromise and the contributing factors are critical in deciding between the various basic options available to open the airway. The talk-look-listen-feel approach is taught world wide as part of evaluating a possible compromised airway as well as contributing factors.(1) Utilising basic airway manoeuvres is crucial in stabilising and opening the casualty's airway initially. It is sometimes the only option available to a health care provider and sometimes it is the only manoeuvre necessary in stabilising the airway of the casualty.

Talk to the casualty. An appropriate reply in a normal voice indicates a patent airway, sufficient breathing and adequate brain perfusion for that moment. Any inappropriate or incomprehensible response suggests a decreased level of consciousness, airway compromise, breathing compromise or all three. (1)

Look for chest rise, obstruction/foreign bodies in the mouth and pharynx - any abnormal behaviour like agitation, confusion, drowsiness and signs of cyanosis can indicate oxygenation compromise. (1)

Listen for any signs of breathing, any abnormal sounds. Partial obstruction of the larynx can produce snoring, gurgling (mostly liquid) and gargling sounds. Laryngeal injury and or swelling can cause hoarseness or stridor. (1)

Feel for expired air which will indicate breathing attempts. Feel if the trachea is in the midline. Although this is a very late sign and should not be relied upon, it can indicate a possible tension pneumothorax (1).

Any possible compromise should be addressed immediately to improve oxygenation and to prevent further deterioration of the casualty.

Clearing of the airway:

Visible foreign bodies can be swept out of the mouth with a gloved finger. A Magill's forceps could also be used (if the object could safely be grabbed without

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ABSTRACT

Deciding which patient to treat first when more than one patient requires medical treatment is a decision that must be made on scientific grounds. The use of evidence-based triage protocols could significantly help medical personnel in making the decision.

Patients are prioritised into categories according to the life or limb threatening level of their injuries. The higher the category, the more severe the injuries and the more urgent the medical treatment required.

Triage SIEVE is a model based on the mobility and ABC (Airway, Breathing and Circulation) presentation of the patient. This model is used to perform initial / primary triage and is presented in an easy-to-follow algorithm.

Triage SORT takes into consideration anatomical and physiological parameters of the patient. Clinical knowledge and experience are important in the interpretation of the patient's presenting signs and symptoms in order to make a decision.

On the battlefield, reversed triage may be used. In this scenario, the patients with minor injuries are treated before patients with more serious injuries in order to return them to the battlefield.

INTRODUCTION

Triage was initially developed by Dominique Jean Larrey (1,5), a surgeon during the Napoleonic Wars (1803-1815). He realised that casualties must be sorted into priorities of care to optimise care without taking their military rank into consideration. His objective was however to treat the less injured first to get them back to battle as soon as possible.

Triage existed in the past but only informally. It was only during World War I (5) (1914 – 1918)that formalised triage was initiated by French doctors who were treating the wounded on the battlefield as well as at the aid stations behind the front.

Until recently, triage was frequently performed as a matter of “the best guess” based on the experience and perception of the triage officer as opposed to a meaningful assessment based on repeatable criteria.

In the past, victims of war or casualties were prioritised according to three basic categories:

- Those who are likely to live, irrespective of what care they are going to receive
- Those that are likely to die, irrespective of what care they are going to receive
- Those for which immediate care might have a positive outcome

The modern-day approach in triage of casualties has become more scientific, based on scientific criteria and repeatable by different triage officers. Patients are now classified according to the following categories (4,5):

P1: Critical: Those in need of immediate life-saving treatment.
P2: Urgent: Those in need of medical treatment that can be delayed for a limited time period.
P3: Minor: Those in need of minor medical treatment.
P4 (P1 Hold): Patients not salvageable with the resources available or who are so severely injured that they cannot be saved.

Dead: A patient that is dead. As there is no priority coupled to the management of the dead, corpses are not allocated a priority.

During the primary or initial triage, the clinical interpretation and the knowledge of the specific signs and symptoms of the wounded soldier's injuries are not needed (5). Initial or primary triage is thus based on an easy-to-follow algorithm. Due to the simple nature of the algorithm, non-clinical staff (eg pharmacists, social workers, and psychologists) can be used at this level as triage officers. This will leave trained and skilled medical staff (Operational Emergency Care Practitioners, Nursing Officers and Medical Officers) free to initiate treatment of the wounded soldier.

Secondary triage is more scientific and clinical knowledge-based (5). Specific signs and symptoms are taken into account in the assignment of a specific triage priority. Personnel that perform secondary triage thus require clinical training and experience.

The aim of triage is to ensure the *greatest good* (care) for the *greatest number* of casualties to ensure the optimal utilisation of medical personnel, equipment, and facilities (4,5).

TRIAGE PRIORITIES

Within the South African Military Health Service, as in the Emergency Medical Services three standard triage priorities are distinguished with a possible forth grouping used in exceptional circumstances.

Priority 1 - Critical

Patients classified as Priority 1 (P1) require immediate interventions or even surgery in order for their life or limb to be saved. To put it more simply, if the patient does not receive immediate medical attention, the patient will die. The key to successful triage is to identify these individuals as quickly as possible. Examples of patients in this category include, but are not limited to, haemodinamically unstable patients with airway obstruction, chest or abdominal injuries, massive external bleeding, or shock (4). As a planning norm, this grouping on average represents 10% of the live casualties in battle or in a major incident. If a colour coding system is used, this category is marked RED.

Priority 2 - Serious

Patients classified as Priority 2 (P2) are injured in such a way that they might require surgery or constant medical attention. The patient's general condition, however, permits that if surgery is needed; it may be delayed for a couple of hours. Examples of injuries that would be as signed to a P2 category include, but are not limited to, large tissue wounds, fractures to the major bones, intra-abdominal or thoracic wounds or burns to less than 20% of the body surface area. Medical treatment such as splinting and pain control will be required (4). On average this priority represents 15% of the surviving casualties. In a colour coding system, this category is marked YELLOW or ORANGE.

Priority 3 – Non-Urgent or Minor

Patients classified as Priority 3 (P3) have minor injuries, the so-called walking-wounded. They do not require immediate life saving medical interventions. When colours are used to indicate the classification, P3 is indicated by GREEN. Examples of patients in this category include, but are not limited to, small burns, lacerations, abrasions and small fractures(4).This priority is on average the largest group of casualties and represents 75% of the surviving casualties[1].

Priority 4 (or P1 HOLD)

Patients classified as Priority 4 (P4)are so severely injured or moribund that their chance of survival is almost non–existent, given the resources available for their treatment (4,5).In some triage systems, the terms **P1 Hold** or **expectant** are used to identify this category of patients.

The P4 priority is the casualty who would have been a P1 priority, if there were adequate resources available. However, with the P4 priority, the treatment of the patient cannot be initiated with the resources available at that moment in time.

The P4 priority is activated to do "the greatest good for the greatest number of patients" taking into account the limited resources available. If more resources become available, any surviving P4 patients are immediately re-triaged to P1 for immediate care (6).

[1] It is emphasised that the distribution of 10% Priority 1, 15% Priority 2 and Priority 3 75% are planning norms based on analysis of battlefield statistics.

Health Care Management of Radiation Casualties

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ABSTRACT

All humans are exposed to certain levels of naturally occurring radiation without any harm. Ionizing radiation is radiation that causes ionisation of atoms and is potentially harmful to humans.

The effects of ionising radiation on humans are the result of changes to the DNA and other sub-cellular structures with resultant cellular damage that may be repairable or may result in cellular death. Radiation effects are determined by dose rates, time of exposure and distance from the source of radiation.

High dose rates may lead to Acute Radiation syndrome, which consists of four elements, namely haematopoietic syndrome with depression of blood forming organs, gastrointestinal syndrome affecting the gastrointestinal system, neurovascular syndrome affecting the brain and muscles, and cutaneous syndrome affecting the skin.

Treatment of radiation patients is primarily supportive by some additional specialised procedures such as stem cell transplantation when required.

The health care management of patients exposed to radiation is complex and demands a well coordinated multidisciplinary effort. Therefore, it is necessary that health care personnel have some knowledge of the effects and management of radiation injury.

The fact that the effects of radiation occur after a time period indicates that the primary responsibility of emergency workers at the incident is to determine the presence and levels of radiation through well

documented information and monitoring, while treatment will primarily occur at hospital level.

INTRODUCTION

All living creatures are exposed to certain levels of radiation (background radiation) that occurs naturally due to trace amounts of radioactive materials that occur everywhere; in the soil, building materials, food and drink, the air, our own bodies (muscles, bones, and tissue) and sea water. The earth is also subject to radiation from outer space called cosmic radiation. Background radiation must always be taken into account when radioactivity is measured.

Humanly produced radiation, such as X-rays, radiation for diagnostic procedures and cancer therapy, and small quantities of radioactive materials released into the environment from coal and nuclear power plants are also sources of radiation.

TERMINOLOGY

In order to have a clear understanding of all the aspects related to radiation, it is necessary that some concepts are described.

Atomic Structure

The atom is the basic unit of all matter. It consists of a nucleus around which one or more electrons circle. The nucleus consists of protons and neutrons. Electrons are negatively charged, protons are positive and neutrons have no charge. In most atoms there are an equal number of electrons and protons and, therefore they have no electrical charge (1,2).
Atoms combine to form molecules which are the building blocks of matter.

Ionisation

An ion is an atom that has an electrical charge due to an imbalance between the numbers of protons and electrons.

Ionisation is the process in which an atom or molecule is converted to an ion by adding or removing electrically charged particles (electrons or protons) from the atom or molecule (1, 2).

Radioactivity

Some natural elements are unstable; their nuclei tend to disintegrate with resultant release of energy in the form of radiation. This phenomenon is called radioactivity. Radioactive atoms are called radionuclides (1, 2).

Ionizing Radiation

The radioactive emissions listed above will increase the ability of any medium through which they pass to conduct an electrical current, in other words, they will ionise that medium. Therefore, the radiation caused by these emissions is called ionizing radiation (1).

In living tissue ionizing radiation causes damage to organic molecules and therefore, to living cells and tissues. In this regard DNA is of particular importance.

Non-Ionizing Radiation

Non-ionizing radiation does not have the amount of energy needed to ionize an atom with which it interacts.

Sources of non-ionizing radiation include sunlight, microwaves and infrared lights.

Radiation types

There are four known types of ionizing radiation:

a. <u>Alpha Radiation</u>. Alpha radiation is produced by alpha particles. Alpha particles are heavy, positively charged particles emitted by

large atoms of elements such as uranium and radium. They can only travel a short distance (2,5 – 4 cm) in the atmosphere and can be stopped completely by a sheet of paper or by the epidermis. However, if alpha-emitting materials are taken into the body, they will cause serious biological damage to living cells (1, 2).

b. Beta Radiation. Beta particles cause Beta radiation. Beta particlesare high-speed electrons. They can travel up to 3m through the air and are more penetrating than alpha particles. They can pass through up to around 1 cm of water, but are shielded by plastic safety glasses and thin metal sheeting such as aluminium. Beta particles pose an external and internal hazard to humans (1,2).

c. Gamma Rays. Gamma rays are not material particles, but energetic photons of invisible light. Depending on their energy, they can pass right through the human body, but can be stopped by thick walls of concrete or lead. Gamma rays pose external as well as internal hazards (1,2).

d. Neutrons. Neutrons are uncharged particles and do not produce ionisation directly, but their interaction with the atoms of matter can give rise to alpha, beta, gamma, or X-rays that then produce ionisation[2]. Neutrons have a long range, are relatively penetrating in tissue, but are shielded by hydrogenous materials such as water and paraffin.

EXPOSURE TO IONISING RADIATION

The factors influencing the effects of ionizing radiation are the dose of radiation the tissue receives, the duration of exposure as well as the distance from the source of radiation.

Exposure can be acute, prolonged or intermittent. It can occur alone or in combination with other injury.

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Patients classified as Priority 2 (P2) are injured in such a way that they might require surgery or constant medical attention. The patient's general condition, however, permits that if surgery is needed; it may be delayed for a couple of hours. Examples of injuries that would be as signed to a P2 category include, but are not limited to, large tissue wounds, fractures to the major bones, intra-abdominal or thoracic wounds or burns to less than 20% of the body surface area. Medical treatment such as splinting and pain control will be required (4). On average this priority represents 15% of the surviving casualties. In a colour coding system, this category is marked YELLOW or ORANGE.

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The P4 priority is activated to do "the greatest good for the greatest number of patients" taking into account the limited resources available. If more resources become available, any surviving P4 patients are immediately re-triaged to P1 for immediate care (6).

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[1] It is emphasised that the distribution of 10% Priority 1, 15% Priority 2 and Priority 3 75% are planning norms based on analysis of battlefield statistics.

Patients in this priority must still be provided with comforting measures and pain medication and must be treated with the necessary respect (4).

TRIAGE SIEVE

The Triage Sieve method (Diagram 1) can also be referred to as primary or initial triage (5). Triage Sieve is used as an initial tool for the fast and simple prioritising of a large number of casualties simultaneously.

Triage Sieve is a quick “first look” triage to prioritise the many casualties for care. Clinical interpretation on how the patient’s condition may change must not be taken into consideration. As the Sieve method is a simple procedural method of triage, the use of non-clinical personnel to perform Triage Sieve may be considered during this phase to optimally use clinical personnel to provide emergency interventions and execute more advance triage procedures.

Triage Sieve is based on two fundamental principles: Mobility and the ABC (Airway, Breathing and Circulation).

Mobility:
The first step is determining the mobility of the patient. Patients that can still walk are prioritised as P3. It does not matter if the patient has a laceration, fracture, or any other injury. As long as the casualty is able to move/walk on his/her own he/she is prioritised as a P3 patient. The patient is immediately directed to the P3 treatment area.

Should the patient be seriously injured, but able to walk he/she is still triaged as P3 at this stage and is directed to the P3 treatment area where skilled medical staff evaluates every patient using secondary triage methods.

Airway and Breathing:

The second step is to determine whether the casualty is breathing. If the casualty is not breathing, the airway is opened with simple airway manoeuvres such as chin-lift or jaw-thrust and breathing effort re-assessed. If breathing is absent, the patient is considered to be dead[2].

If breathing is detected once the airway is opened, the patient is prioritised as P1 - *airway problem.* This patient is immediately transferred to the P1 resuscitation area*.*

For casualties who were breathing, the respiratory rate is used as a tool to determine effectiveness of ventilation. If the respiratory rate is **below 9** or **above 30,** the casualty is prioritised as P1- *breathing problem.* This patient is immediately transferred to the P1 resuscitation area*.*

If the breathing rate is **between 10 and 29**, continue to the next step on the Triage Sieve algorithm assessing circulation.

Circulation:

The third step is to do an assessment of the circulatory status of the patient. Circulation is assessed by means of the pulse rate (radial). If the pulse rate is **above 120,** the casualty is prioritised as P1 - *circulatory problem.* This patient is immediately transferred to the P1 resuscitation area*.*

Capillary Refill Time (CRT) can also be used as an indicator of the circulatory status, however, evaluating capillary refill time might be difficult in the combat scenario due to austere conditions. In the dark, sufficient light is needed to accurately assess capillary refill time. Switching on a light in the dark, austere battlefield environment will make the medical personnel immediate targets. Cold conditions and subsequent hypothermia also make CRT an unreliable indicator. Assessing CRT needs to be used with caution. . If the capillary refill time is longer than 2 seconds, the casualty is prioritised as P1 – circulatory problem.

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[2] It must be emphasised that Triage Sieve is used in the Major Incident or disaster situation where a large number of patients need to be assessed and prioritised in the shortest possible time. It is within this environment that the patient with an open airway that is not breathing is classified as dead. If more resources are available, the more advance Triage Sorting tool may be utilised.

P2 ALLOCATION

If all of the abovementioned criteria are within the normal limits of the algorithm, the casualty must be prioritised as a P2 priority and transferred to the P2 treatment area. P2 patients therefore have a pulse rate of less than 120 beats per minute or a capillary refill time of less than 2 seconds.

TRIAGE SORT

Triage Sort (Diagram 2) is performed as the secondary triage (5). Triage SORT is thus performed when more resources, time and skilled personnel are available, such as at the stabilisation point, the Level 1 Resuscitation Post and at the Level 2 Field Hospital. Often, when a large group of patients arrive simultaneously, they are first triaged using the sieve method to get them into specific categories, then every category is revisited and the casualties re-evaluated using the more refined Triage Sort method.

Diagnostic equipment (blood pressure monitors) must be available to aid in assigning triage priorities.

Triage Sort is a physiological measure of the severity of the casualty's injuries based on the following three parameters: Glasgow Coma Score, Respiratory rate and Systolic Blood Pressure.

Step 1: Determine the Glasgow Coma Score of the casualty.

Step 2: Determine the Systolic Blood pressure of the casualty.

Step 3: Determine the Respiratory rate of the casualty and convert the respiratory rate to a value using the scale provided.

Step 4: Assign a score according to the measured value for each physiological variable.

S No	**Physiological Variables**	**Measured Value**	**Score**
	A	**b**	**C**
1	*Glasgow Coma Score*	3 4-5 6-8 9-12 13-15	0 1 2 3 4
2	Systolic Blood Pressure	0 <49 50-75 76-89 >90	0 1 2 3 4
3	Respiratory Rate	0 1-5 6-9 >30 10-30	0 1 2 3 4

Table 1: Measured Values and Scores of Physiological Variables

Step 5: Add up the allocated scores: Glasgow Coma Scale + Systolic Blood pressure + Respiratory Rate. (Note the original Glasgow Coma Score total is not added in but only the converted score is used)

Step 6: Determine the triage priority according to the accumulative score.

S No	Score	Triage Priority
	A	**B**
1	1-10	Priority 1
2	11	Priority 2
3	12	Priority 3
4	1-3	Priority P1 Hold/ P4
5	0	Dead

Table 2: Triage Sort – Score and Triage Priority

Step 7: Take into account anatomical and physiological aspects that may have an effect on the nature of the injury. The Triage Officer may use clinical judgement and assign a higher triage priority to the patient based on specific findings indicating the need for more urgent treatment of the patient. It must be emphasised that the use of clinical judgement to upgrade a patient's triage priority must be based on observed findings and not on possible deterioration of the patient's condition. For example, a walking casualty with facial burns may be heamodynamically stable and based on clinical findings be categorised as a Priority 3 casualty, however, due to clear facial burns, singed facial hair and soot on the tongue, the patient requires intervention to maintain an airway and is therefore upgraded to a Priority 1 - airway patient.

This action must, however, be used with great caution to prevent large numbers of casualties being upgraded to Priority 1 based on assumed possible complications and cluttering the emergency treatment capability.

TRIAGE IN THE OPERATIONAL SCENARIO

The choice of which triage system to use in the operational scenario will depend on the location and resources available (1).

On the battlefield, triage takes place within an area with already limited resources. Triage determines if casualties should receive immediate treatment, eg application of a tourniquet

to stop catastrophic bleeding, or whether transfer to the stabilisation point is possible. In this situation, Triage Sieve will be applied continuously and repeated at each point in the evacuation chain until the casualty reaches an area where a more refined triage method can be used. This is often only possible when the casualty reaches the Level 1 Resuscitation Post.

Basic principles that can aid in the triage process on the tactical battlefield environment are (4):

1. Movement of the casualty and attendant out of danger take precedence over a life saving procedure or other medical interventions. Casualties who are not clearly dead may be moved to cover, if possible, and/ or on command of protection forces.

2. Perform an initial rapid assessment of the casualty as soon as cover is reached. This assessment should not take longer than 60 seconds (1 minute) per casualty and includes Triage Sieve.

3. Treat any life-threatening haemorrhages and perform life-saving interventions as needed. For example, to open airways, stop bleeding and stabilize injured limbs will save lives and reduce further injuries. Pressure dressings and tourniquets are very useful tools to prevent catastrophic bleeding, which is a major cause of deaths on the battlefield.

Please take note that these principles apply to the combat scenario where there are limited resources. Care under fire poses a lot of challenges to the medical personnel, especially with haemorrhage control that takes priority.

Initiating the *Priority 4 (P1 HOLD or expectant) category* can be forced by the tactical situation. It is thus advisable to obtain sanction from the higher headquarters (HQ) to initiate the Priority 4 category at the Level 1 Resuscitation facility. The higher HQ is more aware of the complete tactical situation at hand and the possibility of receiving more resources. If more resources become available or, due to the tactical situation, no more patients will be arriving at the specific facility, all currently available resources can be used for the treatment of the patient. If, however, the higher head quarters are aware of a hostile action taking place with resulting large numbers of casualties, it may advise that the Priority

4 category is used to free-up resources for additional casualties that are on the way. It must be emphasised that the decision to activate the Priority 4 category is seldom taken and must be based on a proper tactical appreciation of demand versus resources.

The United States of America Marine Corps describe the principles of tactical / battlefield triage as follows (5):

1) To accomplish the greatest good for the greatest number of casualties.
2) To employ the most efficient use of available resources.
3) To return personnel to duty as soon as possible (Reverse Triage).

REVERSE TRIAGE

In some situations the preservation of fighting power may be of utmost importance for the survival of the element. In these instances it might be necessary to treat less seriously wounded or injured before the severely wounded or injured casualties to get them back fighting. As the less injured are treated to the level that they can return to the fighting, efforts can then be redirected to the seriously wounded that will require all available resources to be treated. This concept is called reverse triage where Priority 3 casualties are treated/stabilise first to get them back fighting, then try to save the priority 1 and 2 casualties.

in certain scenarios, it might be of the utmost importance to direct the medical resources first towards the injured medical personnel as this may be advantageous to ensure that they survive to continue with the treatment of the injured soldiers / casualties.

Triage is not a democratic decision-making process and requires very tough decisions in a very short time. The “return to battle” or a “fight to save the ship” is a tactical scenario that may take precedence over “best medical care practice” (1,2). The decision to initiate reverse triage can thus be forced by the tactical situation and not only by the clinical decision making process.

RE-TRIAGE

Triage is never a one-off process. It is repeated continuously at every link of the evacuation process and after each intervention. At arrival on the scene of a Ratel vehicle that was shot out by enemy fire, that has been declared safe by the fighting element, the medic will assess all casualties using Triage Sieve and allocate priorities. The team will then use these priorities to extricate the casualties from the vehicle to a stabilisation point. At the stabilisation point all casualties are re-triaged using Triage Sieve to determine their present condition to determine the need for intervention. After interventions, for example, inserting a naso-pharyngeal airway and applying a bomb bandage, the casualty is re-triaged as his/her condition may now be more stable. This process is repeated continuously.

EVACUATION

Two key factors must be considered in making a decision on the evacuation of a casualty to a higher level of care, namely the current triage priority and the required treatment(5). These two factors are used to triage the casualties for evacuation.

Triage Priority

As indicated above, the patient must be re-triaged after receiving any form of treatment. Additional criteria must then be added to determine the evacuation priority. The triage priority alone may not be the sole determination for evacuation priority. The availability, type and capacity of vehicles are examples of additional criteria that must be kept in mind and added during the decision making process regarding the patient's evacuation priority. If, for example, after initial treatment the patient is re-triaged and his/her priority has changed from P2 to P3, a sophisticated means of transport is not needed and his/her need for immediate transport to a higher facility is less urgent. The first available mode of transport may not be the appropriate mode for the specific casualty and the team may decide to evacuate the priority 2 casualties with the available ambulance and hold the priority 1 casualty back for the helicopter confirmed to be landing within a few minutes' time. The most appropriate means of evacuation must be used to ensure that each patient reaches the next level of care alive.

Treatment

The correct amount of treatment is necessary to ensure that the patient survives to the next level of care. According to the patient's priority classification, treatment and packaging must be restricted to what is necessary for safe and effective evacuation. An unstable casualty results in an unstable evacuation. It may be indicated to hold back a higher priority to complete preliminary stabilisation while a lower priority casualty is evacuated first.

Often the team is confronted with two or more casualties with the same triage priority, but only space to evacuate one casualty. In this type of situation, the criteria of who will benefit the most by the treatment at the next level of care must be considered as additional criteria to determine evacuation priority.

Evacuation triage, therefore, not only uses Triage Sieve or Sort, but also considers the additional criteria of treatment requirement to determine the evacuation priority.

CONCLUSION

Casualties must be triaged at every link of the evacuation process (chain) as triage is a dynamic process and the casualty's condition can deteriorate at any time, or improve after received treatment.

Triage in the tactical situation is an art that requires situational awareness, decisiveness and clinical expertise. Each decision is driven by factors such as the personnel versus the casualty ratios, provider skills, accessibility of equipment, and the availability of evacuation, communication and supplies. Time, distance and weather may also play significant roles as do fatigue, confusion and panic(1). Triage Sieve provides the tool for scientific triage at this level. This can be done by any person available on scene.

As soon as a casualty reaches more appropriate levels of care where more resources are available, a more detailed triage process can be used. Triage Sort provides the tool for this assessment, but requires clinical knowledge, equipment, time and capability to calculate scores. It is recommended that it is used from the Level 1 Resuscitation Post to the Level 3 Specialist Hospital.

The category of Priority 4 is a very specific category reserved for very specific situations where the need totally overwhelms the available resources and it is very seldom activated.

Reverse Triage refers to a unique system to optimise treatment to preserve fighting power in a desperate battlefield situation.

Evacuation Triage uses the same system but additional criteria are taken into account.

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Triage SIEVE

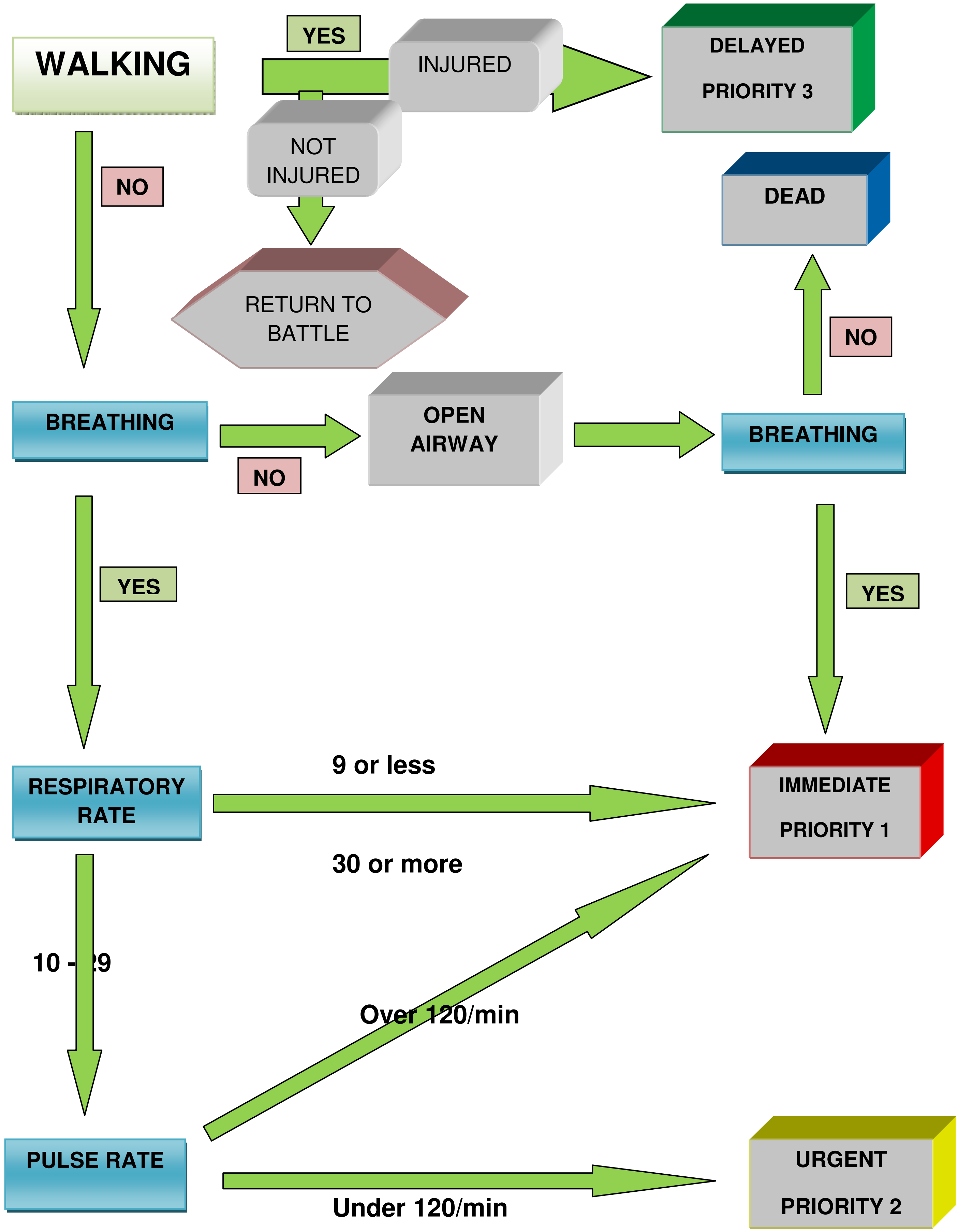

Diagram 1: Triage SIEVE

Recognition of airway compromise and the contributing factors are critical in deciding between the various basic options available to open the airway. The talk-look-listen-feel approach is taught world wide as part of evaluating a possible compromised airway as well as contributing factors.(1) Utilising basic airway manoeuvres is crucial in stabilising and opening the casualty's airway initially. It is sometimes the only option available to a health care provider and sometimes it is the only manoeuvre necessary in stabilising the airway of the casualty.

Talk to the casualty. An appropriate reply in a normal voice indicates a patent airway, sufficient breathing and adequate brain perfusion for that moment. Any inappropriate or incomprehensible response suggests a decreased level of consciousness, airway compromise, breathing compromise or all three. (1)

Look for chest rise, obstruction/foreign bodies in the mouth and pharynx - any abnormal behaviour like agitation, confusion, drowsiness and signs of cyanosis can indicate oxygenation compromise. (1)

Listen for any signs of breathing, any abnormal sounds. Partial obstruction of the larynx can produce snoring, gurgling (mostly liquid) and gargling sounds. Laryngeal injury and or swelling can cause hoarseness or stridor. (1)

Feel for expired air which will indicate breathing attempts. Feel if the trachea is in the midline. Although this is a very late sign and should not be relied upon, it can indicate a possible tension pneumothorax (1).

Any possible compromise should be addressed immediately to improve oxygenation and to prevent further deterioration of the casualty.

Clearing of the airway:

Visible foreign bodies can be swept out of the mouth with a gloved finger. A Magill's forceps could also be used (if the object could safely be grabbed without

pushing it deeper into the airway). Fluid like blood and secretions can safely be suctioned under vision with a rigid suction tip (2). Suction devices will only become available once the casualty is transferred from the battlefield.

Vomitus however can not be suctioned away quickly enough before the casualty needs to take another breath. During vomiting, the casualty should be turned on his/her side while maintaining inline stabilisation of the neck to allow clearing of the airway, whether suction is available or not.

Rolling onto the side / Recovery Position:

If a casualty is breathing on his/her own with signs and symptoms indicating sufficient oxygenation, the casualty can be turned on his/her side to keep the airway open. In a trauma casualty, the logroll method is preferred due to a potential neck injury but can only safely be done when enough rescuers are available. One rescuer provides inline stabilisation of the head and neck of the casualty. The rest of the rescuers then help to turn the casualty as a unit under direction of the rescuer at the head.

The airway has priority over the C-spine. Open the airway as soon as possible with the safest method, however, if no other rescuers are available and logroll cannot be done; the breathing casualty should be turned on his side (potentially risking a spinal injury)

Chin lift:

The chin lift (without head tilt) is safe to use in a potential neck injury. The forefingers and thumb are used to lift the chin upwards and the thumb can also open the mouth by gently pressing on the chin/lower lip. The rescuer can stabilise the head by putting his/her other hand on the casualty's forehead (1,2,3,4).

The head tilt; chin lift manoeuvre can only be used in the casualty without any possible spinal trauma.

Jaw thrust:

The mandible is displaced upwards and forwards with both thumbs on the casualty's zygomas and the index and middle fingers under the angle of the mandible. (1)

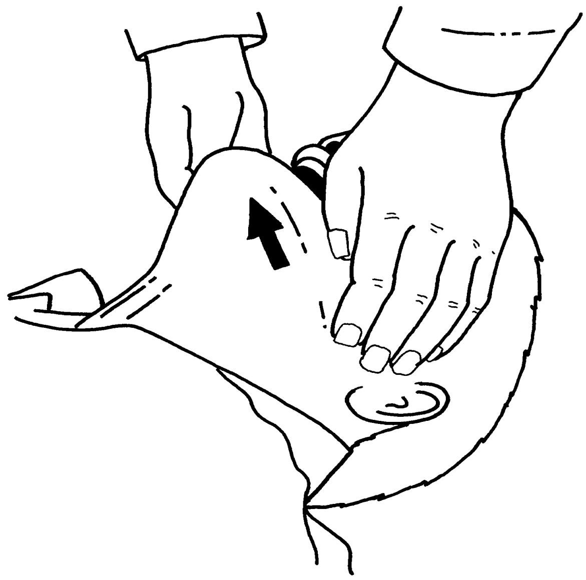

Figure 1: Jaw thrust (From: BATLS Manual 2006 Edition)

Barrier devices:

Assisted ventilation can be achieved by mouth-to-mouth ventilation, but the fear for contracting communicable diseases makes this an unattractive option. Commercial devices that minimize this possibility exist in the form of barrier devices like face shields. The pocket mask with a one-way valve can also be used to minimize the risks and oxygen supplementation can be used with this method. A barrier device should be part of the buddy aid kit on every soldier's bag. These techniques are not safe if a chemical agent vapour hazard exists. (1)

Bag-mask ventilation:

A bag-valve-mask (BVM) or resuscitator bag can be used to assist ventilation in a casualty with poor oxygenation. This technique can be performed by one or two rescuers, with the two rescuers being the preferred method, especially if the one hand (or one rescuer) technique is not providing adequate oxygenation. Adequate bag mask ventilation is usually evident with chest expansion and clinical improvement in the patient. (3,5) If oxygenation is not optimal with the bag or the chest not rising, check for mask seal (eg KY gel on a bearded patient or reinserting casualty's false teeth or place gauze inside the mouth to create a more anatomical mask seal), rule out a foreign body in the airway, check jaw-thrust manoeuvre effectiveness, release cricoid pressure (if used), all possible upper airway adjuncts already in use or ask a more experienced person to perform manoeuvre (5,6).

Supplemental oxygen with a reservoir bag can give inspired oxygen concentrations of >90% if the reservoir bag is not deflated during ventilation and a good seal is provided. (6)

Oropharyngeal airway:

The oropharyngeal airway (Guedel type or OPA) is only used in casualties without a gag reflex and stops the tongue from falling back by inserting it over the tongue. The preferred insertion method is to direct the airway concavity over the tongue after the tongue has been pressed out of the way with a tongue depressor. The old method of inserting the airway concavity upwards until the tip reaches the soft palate and then rotate it 180^{o}, slipping it into place over the tongue can cause damage to the soft palate and will only be recommended if no tongue depressor can be found (eg laryngoscope blades, teaspoon, small branch etc) (5,7,8).

Nasopharyngeal airway:

The nasopharyngeal airway provides oxygen to posterior pharynx and can be used in a casualty with a gag reflex. Correct sizing is important and measurement extends from the nares to the trachus/earlobe (adjust safety pin if necessary) and the diameter of the inside aperture of the nares (1,4,5,7). Assess for obvious nasal passage obstruction before insertion and lubricate the airway well. Insert the tip into the nostril and direct it posteriorly towards the ear with a slight rotation motion until the safety pin rests against the nostril. Epistaxis can occur in up to 30% (9) of cases, but direct pressure will usually be enough to stop the bleeding.

Figure 2: Oropharyngeal airwaysFigure3: Nasopharyngeal airway   Figure 4: Partial rebreather

Supplemental oxygen masks:

Supplemental oxygen should be provided to any casualty as soon as it becomes available, but due to the scarce availability on the battlefield, it should be used on the casualty with the greatest need for oxygen (see TCCC guidelines table 1). If a casualty is breathing on his/her own and does not need assisted ventilation with a BVM, an oxygen mask will deliver supplemental oxygen safely. The partial rebreather mask can produce inspiratory oxygen percentages of 60% and higher owing to a reservoir bag (which should never deplete during ventilation). (4,5,8,10,11)

ADVANCED AIRWAY MANAGEMENT

An advanced airway device should be used if the above basic airway manoeuvres and devices cannot obtain sufficient oxygenation and ventilation. A

vast amount of different advanced airway devices are available on the market and it is the health care provider's responsibility to decide which device would be best in the different circumstances and according to his/her scope of practice. On the battlefield, it is sometimes better to place an advanced airway in a compromised airway before moving on to the next casualty – it is easier for a fellow soldier to quickly learn how to squeeze a bag than to ventilate the casualty with a mask. (12)

Endotracheal intubation:

The only safe airway is a cuffed tube in the trachea because it prevents aspiration. A properly placed endotracheal tube whether orally or nasally and a properly placed surgical airway, whether it be a cricothyroidotomy or tracheostomy, are thus the only safe airways.

The endotracheal tube is a cuffed, single-use tube placed through the vocal cords which allows delivery of high flow oxygen and selected tidal volume to maintain adequate ventilation. (7) This technique usually needs sedative and neuromuscular-blocking agents to facilitate smooth intubation as is done in rapid sequence intubation (RSI) unless the patient is deeply unconscious. Medication for RSI will only be available at the resuscitation post.(3) Good preparation and anticipation of a possible difficult airway is critical in planning for the intubation. (13) Indications for intubation would be to obtain and maintain an open airway, to protect the airway, to correct inadequate oxygenation and ventilation and to intervene early because of the predicted clinical course. (8,13) A full description of the steps in RSI is beyond the scope of this article. Tracheal intubation should only be attempted after proper training and after gaining extensive experience because doing it wrong can turn an injured casualty into a dead casualty.

Clinical confirmation (usually subjective signs) of correct tube placement would be to see that the tube goes through the cords (the best proof)(13),auscultation

of chest, chest rising, vapour in the tube (seldom) and clinical improvement of cyanosis.

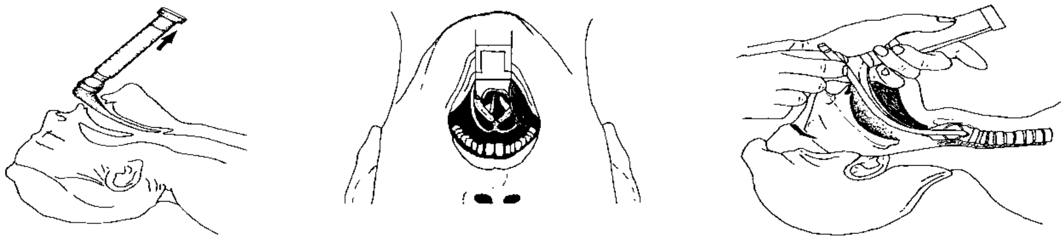

Figure 5: Endotracheal intubation (From BATLS manual 2006 edition)

Commercial devices (usually objective signs) are the only really objective proof of correct placement. The oesophageal detector device (EDD) and exhaled CO_2 detection devices are both available and both can be used at all levels of care. (5,6,8) The principle behind the oesophageal detector device use is the collapse of the oesophageal walls if negative pressure is applied to the endotracheal tube and in the trachea this does not happen. It comes as a 60cc catheter tip syringe or a rubber bulb(better success rates). After intubation, it is attached to the endotracheal tube. If the plunger stays out with negative pressure, it implies correct tube placement. If the deflated bulb attached to the endotracheal tube inflates immediately/quickly, it implies correct tube placement. A few situations can prohibit the safe use of these devices but overall they have a very high success rate. Exhaled CO_2 can be measured with single use inexpensive devices available and is rapidly becoming a standard of care in the emergency airway management (13). The device is placed in-line at the endotracheal tube connector and the presence of CO_2 will be indicated by a colour change. The specificity of the exhaled CO_2 is 97-100% and the positive predicted value 100% (4,5,6,8,10) and therefore it should be part of the medical officer's bag as the primary confirmation device. (13)

Figure 6: Oesophageal detector device **Figure 7: CO2 Detector device**

Securing the endotracheal tube after verifying correct placement is also of critical importance. Commercial devices to secure the tubes are widely advocated in all studies and textbooks owing to its high prevention rates of accidental tube displacement compared to traditional methods like tape and tie. (5,10,11,15) A commercial device to secure the endotracheal tube should therefore also be part of the medical officer’s bag.

Endotracheal intubation can be difficult, especially in the challenging conditions encountered in the emergency setting, and a few airway tips can help with those difficult situations. Changing the blade of the laryngoscope to a longer blade (usually the problem) or a different type of blade, eg a straight blade might help. Positioning the tip of the blade differently eg directly elevates the epiglottis, or indirectly lifting the epiglottis by placing the tip of the blade in the vallecula might provide a better view. Optimise the position of the casualty by putting his/her head at the end of the bed and increase the stretcher height to prevent bending of the back while intubating (head at belly button of rescuer). The laryngoscope should be lifted along the long axis of the handle and a helper can help with the traction on the handle. An endotracheal stylet should be used with every intubation to help with tip placement. External laryngeal manipulation during direct laryngoscopy will improve glottic exposure. It is pressure applied by the rescuer intubating as backward, upward and rightward pressure (BURP) until visualization of the vocal cords. Another helper can then take over the exact pressure while the intubation is attempted. A bougie can be utilised, especially in situations where the vocal cords cannot be visualised but only the tip of the

epiglottis (Grade 3 Cormack-Lehane). A bougie should be readily available before any intubation attempt to be used immediately if the view causes any trouble. (5,6,8,14)

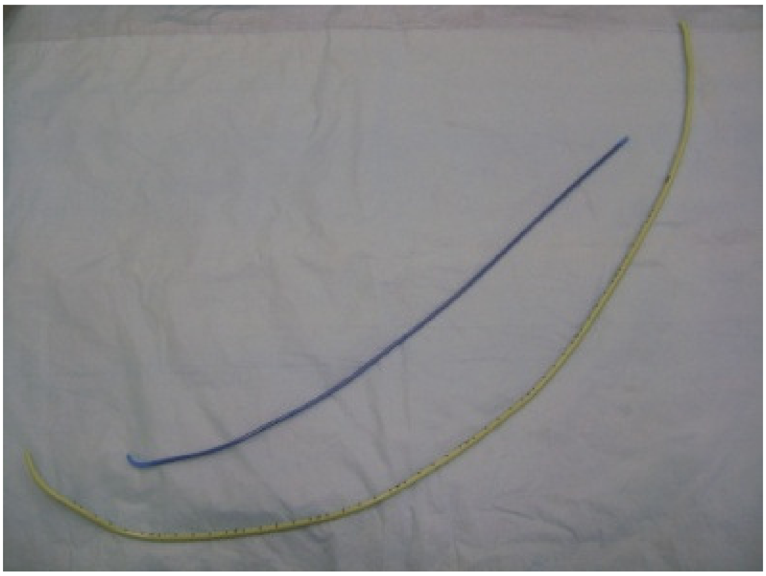

Figure 8: Adult and paediatric bougie

Pulse oximetry can be used to monitor a casualty's oxygen saturation, or actually, the percentage haemoglobin saturated with oxygen. It does not measure oxygen tension or alveolar ventilation but is useful in detecting unsuspected hypoxemia. It has been used with huge success in the battlefield conditions and during transfer to monitor the shocked casualty and to evaluate the result of resuscitation efforts. Hand held models are an ideal option on the battlefield. (13,15)

ALTERNATIVE INTUBATION TECHNIQUES

Alternative intubating techniques should be used if difficult intubation is encountered. A difficult intubation can be defined as a situation where the rescuer had more than two attempts with the same blade, a change of blade or a bougie was used without success and use of an alternative device or technique

was necessary. Alternative intubation techniques would include the Trachlight®, the intubating laryngeal mask airway (ILMA) or the LMA-Fastrach® and an indirect fibreoptic device like the Glidescope or Airtraq®.

The intubating laryngeal mask airway (ILMA) or the LMA-Fastrach® is a shorter, stainless steel barrel laryngeal mask which allows intubation owing to a prominence at the junction of the mask and barrel which directs the flexible, re-enforced endotracheal tube centrally and anteriorly. It is only available in sizes for casualties from 30kg and heavier. Successful insertion and ventilation occur in > 95% of cases and is invaluable in situations with bad vision due to fluid accumulation in the pharynx. (5,6,8,13)

The Glidescope is an indirect fibreoptic device usually only used for training purposes due to financial reasons. The Airtraq® is a new, single use, indirect, fibreoptic device available in SA and relatively inexpensive. The endotracheal tube is attached to the device before insertion and a series of mirrors deliver an image to the proximal eyepiece. (5,6,8) Early studies on manikins show exciting figures but any excessive fluid in the pharynx can lead to poor visibility and difficulty in placing the endotracheal tube through the vocal cords. The latest studies show clearly that the Airtraq provides superior intubating conditions in the difficult laryngoscopy scenarios and has a rapid learning curve. (17,18,19,20)

The ILMA / LMA-Fastrach and the Airtraq should be available at the Level 1 resuscitation post as well as at all higher levels of care. The ILMA or Fasttrach will assist in intubating when a clear view due to secretions / fluid is not possible. The single use version is cheaper and will be ideal in the battlefield. The Airtraq will assist with intubating when visualisation is a problem (eg due to inability to manipulate the position of the patient to extend the neck).

Figure 9: Intubating LMA

Figure 10: Airtraq

Figure 11: Airtraq loaded

SUPRAGLOTTIC DEVICES

The supraglottic devices are utilised in the failed airway situation where three attempts at endotracheal intubation (including an alternative technique/device) failed. Some of the supraglottic devices currently available in SA are the laryngeal mask airway (LMA), the LMA Supreme, LMA Proseal, the oesophageal tracheal Combitube and the King Laryngeal Tube. These devices do not secure the airway, but it might help and buy time in ventilating/oxygenating the casualty while waiting for a more senior rescuer and/or waiting to transfer the casualty to a higher level of care. A supraglottic device should be available in the emergency care bags on the battlefield for rescue ventilation.

The laryngeal mask airway (Classic) was first introduced in 1988 and is well known and widely used in SA and single-use devices in a full range of sizes are also now available. Application does not need direct visualisation of the vocal cords as well as no additional equipment like a laryngoscope but it needs good airway anaesthetisation or deep sedation, e g Ketamine titration would be an excellent choice.(5,6,8)

The LMA Supreme is a single-use laryngeal mask airway newly introduced which has the following features: Modified cuff allowing higher airway pressures, a proximal bite block and a second lumen for oesophageal drainage. The latter makes it an ideal choice for the emergency casualty. This is as the classic

laryngeal mask airway easily used by inexperienced personnel which is a further advantage for use in the emergency casualty. (5,6,8,21)

The oesophageal-tracheal Combitube is currently losing favour as a supraglottic device due to newer and cheaper devices available. The King Laryngeal tube is a new tube with exciting features. It is either reusable or disposable and adult and paediatric versions are available. It has two cuffs inflated simultaneously as well as a separate gastric drainage channel. The latter is again the exciting feature of the laryngeal tube as well as its ease of insertion and its success rate of 97-100%. (5,6,8,21,22)In studies done under Army Combat Medic students the King Laryngeal tube had a success rate of 100% (96% in the Combitube) and was inserted in half the time compared to the Combitube. (24,25)

At this stage the LMA Supremeor the Laryngeal tube would be an excellent choice as a supraglottic device on the battlefield. It will thus be used as a rescue device in the cannot intubate / cannot oxygenate casualty just before a surgical option is tried.

Figure 12: LMA Classic

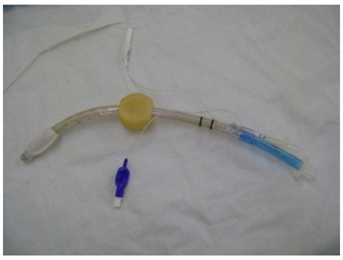

Figure 13: Combitube

Figure 14: Laryngeal Tube

SURGICAL AIRWAY

Usually, the last resort in the failed intubation/failed oxygenation (cannot intubate; cannot oxygenate) is the surgical route. The cricothyroid membrane is usually the area utilised for the surgical airway owing to its ease of location and it is relatively avascular compared to the more distal areas.

Needle cricothyrotomy is falling out of favour due to its limitations in effectiveness and safety. Jet ventilation provides more effective ventilation than low flow oxygen (15 litre/min) due to its higher pressures achieved but also causes more barotrauma and is not readily available in the emergency setting due to the financial implication. (5,6,8)

Surgical cricothyrotomy places a tube into the trachea via the cricothyroid membrane and it can either be done as an open procedure or via a Seldinger technique (more expensive). A vertical skin incision is followed by a horizontal incision through the membrane. A horizontal incision can also be made through both the skin and membrane simultaneously. A small tracheostomy tube (5-6 mm) or small endotracheal tube (size 5 – 6 mm cuffed tube) is inserted and secured. (5,6,8,26)

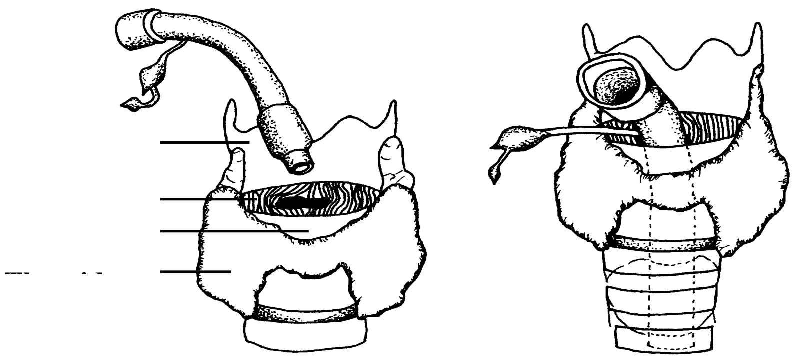

Figure 15: Surgical Cricothyrotomy (From: BATLS Manual 2006 Edition)

TACTICAL COMBAT CASUALTY CARE

The Tactical Combat Casualty Care(TCCC) project started in 1993 after the need for trauma care guidelines in the tactical settings was recognised. Principles and guidelines in this project have been incorporated into the Prehospital Trauma Life Support (PHTLS) course and it is endorsed by the American College of

Surgeons' Committee on Trauma and the National Association of Emergency Medical Technicians. (27)

The Tactical Combat Casualty Care (TCCC) project has identified three phases of care on the battlefield as Care under Fire – care rendered by the medic on the scene, Tactical Field Care – care given by medic when he and the casualty is no longer under hostile fire and Tactical Evacuation Care – Combat Casualty Evacuation Care is care rendered once the casualty has been picked up by an aircraft, vehicle or boat. The three goals of TCCC are: Treat the Casualty, Prevent Additional Casualties and Complete the Mission. (27)

Tactical Combat Casualty Care Guidelines have been suggested by the TCCC projectin 1996 and revised in 2003, 2006 and 2009. These guidelines for effective airway management in the different phases of care in the battlefield are highlighted in table 1.

Care under Fire phase:
• Airway management is generally best deferred until the Tactical Field Care phase.

Tactical Field Care phase:
• Unconscious casualty without airway obstruction:
○ Chin lift or jaw thrust airway manoeuvres
○ Nasopharyngeal airway
○ Recovery position
• Casualty with airway obstruction or impending obstruction
○ Chin lift or jaw thrust airway manoeuvres
○ Nasopharyngeal airway
○ Allow the conscious casualty to assume position that best protects the airway even sitting up

o Recovery position in the unconscious casualty
• If above measures fail:
o Surgical cricothyrotomy (lignocaine if conscious)
Tactical evacuation Care phase:
• Unconscious casualty without airway obstruction
o Chin lift or jaw thrust airway manoeuvres
o Nasopharyngeal airway
o Recovery position
• Casualty with airway obstruction or impending obstruction
o Chin lift or jaw thrust airway manoeuvres
o Nasopharyngeal airway
o Allow the conscious casualty to assume position that best protects the airway even sitting up and recovery position for the unconscious casualty
• If above measures fail:
o Laryngeal mask airway / intubating LMA or
o Combitube or
o Endotracheal intubation or
o Surgical cricothyrotomy (lignocaine if conscious)
• Spinal immobilization is not necessary for casualties with penetrating trauma
• Most combat casualties do not require oxygen, but may be beneficial in following types of casualties:
o Low oxygen saturation by pulse oximetry
o Injuries associated with impaired oxygenation
o Unconscious casualties
o TBI casualties (maintain oxygen saturation > 90)
o Casualties in shock
o Casualties at altitude

Table 1: 2009 Tactical Combat Casualty Care Guidelines (xxvii)

In a study done on 6 875 prehospital combat casualties between Jan 2005 and March 2007 (Operation Iraqi Freedom), advanced airways were use in 293 (4.2%) of the casualties and 97.3% (282) were trauma casualties. The advanced airways were 86.6% (253) endotracheal intubations, 7.5% (23) received supraglottic devices and 5.8% (17) received surgical cricothyrotomies. (28)

CONCLUSION

Management of the airway in a casualty can be a stressful event in any working environment and the previous paragraphs described airway management in the ideal world and work environment. On the battlefield, austere conditions are usually encountered like bad light, extremes of temperature, noisy etc; equipment might be depleted and/or not available and the casualty can either be lightly injured or critically ill. The rescuer can just be a fellow soldier or a highly trained health care provider but both can be tired/hungry/frightened and their level of care would depend on their coping skills as well as previous training.

The health care providers on the battlefield should be proficient in managing the airway of the casualty during all phases of the combat care and have access to the equipment to do so. Training of these individuals should be done on a constant basis and it should include also all the new developments available out there to save the lives of their casualties.

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Basic Mechanical Ventilation in the Operational Theatre

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ABSTRACT

Mechanical ventilation in the austere conditions of the operational theatre could proof intimidating to the inexperienced health care professional. By creating an easy-to-follow flow diagram, basic mechanical ventilation should be achievable and safe, even during austere conditions.

In order to mechanically ventilate a patient, three settings should be applied, namely percentage of oxygen (or fraction of inspired oxygen (FiO_2)), a breathing rate (frequency) and a volume (Tidal Volume (V_T)). The tidal volume administered to a patient must be calculated according to the patient's ideal weight.

After initiating the initial settings, care must be taken to ensure proper oxygen delivery by adding positive end expiratory pressure (PEEP),if necessary, and reducing the peak inspiratory pressure (PIP) to less than 30 cmH_2O.

By using general guidelines for mechanical ventilation, inexperienced health care personnel could safely and successfully ventilate patients, even in austere conditions.

INTRODUCTION

Fear of mechanical ventilation due to a lack of knowledge or lack of exposure and experience should not scare off Health Care Professionals and should not prevent the patient from receiving this type of treatment.

The operational theatre, or battlefield, represents austere conditions where the inexperienced health care professional could potentially withhold the application of a mechanical ventilator due to uncertainty. The result is that the intubated patient will need manual bag ventilation that requires the constant attention of scarce resources, namely personnel, and could lead to over- or under inflation of the patient’s lungs.

The aim of this article is to familiarise the inexperienced health care worker with the basic principles of mechanical ventilation. The focus is thus on the normal healthy soldier, G1K1 classified, that was injured and required intubation. The mechanical ventilation initiated is also for short-term use (24 hours or less) only and the patient should be transported to a higher care facility as soon as possible. The mechanical ventilation of children and complicated ventilatory patients, such as asthma and COPD, is beyond the scope of this article.

OPERATIONAL VENTILATORS

Operational ventilators make use of positive pressure to ventilate the patient. This means that positive pressure is applied to the patient’s airway and this causes flow of gas into the lungs until the ventilator breath is terminated. Patient exhalation occurs as the airway pressure drops to zero, and elastic recoil of the chest then pushes the tidal volume out (1).

To enable the ventilator to deliver the positive pressure to the patient, the ventilator will either need a pressure source or a compressor.

- The pressure driven ventilators need a pressurised oxygen source in order to function. The ventilator does not contain a battery and will thus function as long as the pressure supplied by the oxygen source is enough to drive the ventilator.

- The internal compressor ventilator has its own compressor and can function without the use of additional oxygen. The ventilator does, however, contain a battery and the ventilator will stop when the battery runs flat. If no additional oxygen is needed one can ventilate the patient as long as enough battery power or charging facilities are available. For additional oxygen, the same facilities as the pressure driven ventilator are required.

The choice of ventilator will thus depend on operational circumstances and the availability of logistical support. For example, on the battlefield it is not advisable to carry pressurised oxygen and the ventilator with an internal compressor will be more advantageous, whereas the pressure driven ventilator could be more useful at the resuscitation post where enough oxygen is available and higher oxygen concentrations are required.

INITIAL VENTILATOR SETTINGS

Before any settings on the ventilator are made, one needs to determine the ideal weight of the patient. This is essential, since all ventilator settings are according to the patient's ideal weight (2). An easy to remember "*rule of thumb*" is that the ideal weight for a 1.7 metre tall patient is about 70 kg and for a 1.8 metre tall person it is about 80 kg, etc.

In order to ventilate the patient, three basic variables should be present, namely oxygen, frequency and volume. If one is able to deliver these three variables to the patient, the patient is being ventilated. Consider the following variables:

Fraction of Inspired Oxygen

The Fraction of Inspired Oxygen (FiO_2) can also be translated to the percentage of oxygen that is delivered to the patient. The fraction refers to the total out of one (1), and percentage to the total out of 100. An oxygen percentage of 40% is thus the same as a FiO_2 of 0.4.

Normal room air contains 21% oxygen (3). Ventilating a patient without additional oxygen would thus deliver 21% oxygen to the patient.

The oxygen percentage (or FiO_2) delivered to a patient can be adjusted on the ventilator. Normal adjustments can vary from 21% (room air) up to 100%. Depending on the make of ventilator available, there could either be a dial, knob or a switch that can be turned to select the desired oxygen percentage,. If the ventilator has a switch, the choice of oxygen percentage delivered is severely limited. The standard options are "No Air Mix/Air Mix" or "45%/100%".

The initial FiO_2 setting should be 1.0 (100% or "No Air Mix"). If the patient maintains a SpO_2 above 92%, the FiO_2 can be titrated down to 0.5 (50% or "Air Mix")(2).

When using a ventilator, care should be taken to note the setting of the FiO_2 (or the O_2%) on the ventilator. This setting should also be documented when performing vital sign measurements.

Frequency

Breathing Frequency (Freq) refers to the number of breaths the patient receives in one (1) minute. The normal range of breathing frequency for a healthy adult is 12 – 20 breaths per minute(4). For the purpose of remembering the basics for ventilation, a normal breathing frequency will be taken as 10 breaths per minute. The set frequency of the ventilator should also be noted during vital sign measurements.

Tidal Volume

The Tidal Volume (V_T) is the volume of air entering or leaving the lungs during a single breath (5). The usual recommendations for V_T levels are 8 to 10 ml/kg (2). For the purpose of remembering the basics for ventilation under austere conditions, a value of 10ml/kg will be used. A patient that weighs 70 kg will thus receive a V_T of 700 ml (10ml/kg x 70 kg = 700 ml).

The tidal volume delivered to a patient can be adjusted on the ventilator. Depending on the make of ventilator available, the dial used to adjust the V_T will indicate either V_T or V_M. The V_M indicates Minute Volume.

The Minute Volume (V_M) indicates the volume of air entering or leaving the lungs during one minute. The V_M is calculated by multiplying the V_T with the Frequency, for example, if a patient receives 10 breaths per minute and a V_T of 500 ml, then his/her V_M is 5 litres (10 breaths/minute x 500 ml V_T = 5000 ml V_M = 5 l V_M).

The primary determinant of CO_2 exchange during mechanical ventilation is known as alveolar minute ventilation (V_A). Alveolar minute ventilation is calculated by subtracting the volume of anatomic dead space (the volume of the conducting passages in an adult that average about 150 ml) (V_D) from the V_T and then multiply the value with the frequency [$V_A = (V_T - V_D) \times \text{Freq}$] (2,5). This is important to show that when the VT is increased, the entire increase goes toward elevating the alveolar ventilation, whereas an increase in respiratory rate (Freq) does not go entirely toward increasing alveolar ventilation (5). A respiratory rate of only 10 breaths per minute could thus be safely used with a tidal volume of 10 ml/kg.

The initial ventilator settings are thus as follows: Oxygen percentage = 100% ($FiO_2 = 1.0$) Frequency = 10 breaths per minute Tidal Volume = 10 ml/kg

The above settings are easy to remember, even if a person has not used a ventilator for a long period of time. If the ventilator does not have a Tidal Volume (V_T) setting, but only a Minute Volume (V_M) setting, one only has to set the V_M according to the patient's weight, for example, a patient that weighs 80 kg will have a V_M of 8 litres and a patient that weighs 90 kg will have a V_M of 9 litres.

ADDITIONAL CONSIDERATIONS

By administering the three basic variables, namely oxygen, frequency and volume, the patient is being ventilated. The question is now, 'what other parameters should a person keep in mind?'

Inspiratory pressure

During positive pressure ventilation, airway pressure rises progressively to a peak pressure, which is reached at the end of inspiration. Peak pressure is also called peak inspiratory pressure (PIP) or peak airway pressure. This pressure is the sum of two pressures: the pressure required to overcome airway resistance and the pressure required to overcome the elastic properties of the lung and chest wall (2).

On most ventilators one will notice two important airway pressure-related controls:
The first is the **maximum pressure** setting knob. The maximum pressure allowed during inspiration can thus be set. Depending on the ventilator, the maximum value can differ from 15 cm H_2O up to 80 cm H_2O. The PIP should ideally be maintained at ≤30 cm H_2O. Adverse effects from high inspiratory pressures include barotrauma, volutrauma and reduced cardiac output (2). In order to ensure that the patient is protected against the negative effects of high inspiratory pressures, one should not set the maximum peak inspiratory pressure to exceed 40 cm H_2O. Should the patient's PIP reach 40 cm H_2O, the ventilator will stop delivering the breath, thus protecting the patient from the negative effects of high inspiratory pressures. An alarm will also sound to warn the health worker that a problem has occurred and that his/her immediate attention is needed.

The second control a person might find on the ventilator is a pressure gauge. On the gauge one can note the PIP and record the value together with the vital signs.

Elevated inspiratory pressures may be reduced by the following interventions (2):

- Decreasing Positive End Expiratory Pressure (PEEP) – this action may decrease oxygenation
- Decreasing the V_T – this action may increase CO_2 levels in the blood (Hypercapnia)
- Ensure that the ventilator tube and endotracheal tube are not obstructed

One's decision to lower the PIP should thus be regarded in accordance with the condition of the patient. When poor oxygenation, inadequate ventilation or excessively high peak inspiratory pressures are thought to be related to the patient's intolerance of ventilator settings and are not corrected by adjusting the ventilator, consider sedation and the use of analgesia (2).

Expiratory Pressure

As humans exhale, a certain amount of air remains in their alveoli and is called the functional residual capacity (FRC) (5). This remaining volume creates a pressure inside the alveoli that keeps the alveoli from collapsing. This pressure is called the Positive End Expiratory Pressure (PEEP) (2).

On the ventilator PEEP is a mode that involves the maintenance of positive pressure at the end of expiration, rather than allowing the airway pressure to return to atmospheric pressure as usually occurs. By maintaining the positive pressure, alveoli that would otherwise collapse, are held open, thus increasing the opportunity for gas exchange across the alveolocapillary membrane. This is accomplished by increasing the FRC. The result is a decrease in physiologic shunting and the ability to achieve a higher level of PaO_2 with lower concentration of delivered FiO_2(6). If the patient is already on 100%

oxygen and his/her saturation is still below 90%,one can start to increase the PEEP in order to raise the patient's SaO_2.

PEEP can, however, be hazardous because of the increased intrathoracic pressure. The most important side effects of PEEP are [6]:

- An increased incidence of pneumothorax
- Reduction in venous return – this is especially important in dehydrated or hypovolemic patients. A raise in Intra Cranial Pressure (ICP) could also be experienced due to the decreased venous return.

On the ventilator PEEP can be set if the ventilator is advanced enough to have the function, or by adding a PEEP valve to the expiratory part of the ventilator circuit. The PEEP valve has a knob that can be turned to select the amount of PEEP offered.

Because of the dangers involved with using PEEP, the indications for operational use of PEEP should be limited to patients that are unable to maintain their SpO_2 above 92% on 100% oxygen. A PEEP of 5 cm H_2O should then be started and increased with 1 cm H_2O increments until a maximum of 10 cm H_2O is reached. It is important to remember that by applying PEEP, one will also increase the patient's PIP and the risk for barotrauma. The administration of PEEP should thus also be limited to ensure that the patient's PIP is maintained below 30 cm H_2O.

CHANGING SETTINGS

Even when conducting basic mechanical ventilation, the need may arise to change some of the settings. The question is when and how to make changes to the ventilator settings. For basic mechanical ventilation in the operational theatre, the flow diagram can be used (Diagram 1):

You already know how to set the initial settings for the ventilator and we will now focus on changing those settings. These settings need to be checked together with each vital

sign measurement and charted. Continuous adjustments (after each vital sign measurement) may also be needed.

The aim of mechanical ventilation is to improve gas exchange and thus increase the patients PaO_2. Since the measuring of PaO_2 in the operational theatre is unpractical, we will firstly focus on the patient's SaO_2. Is the patient's SaO_2 more than 90%?

- If the answer is 'NO', one will need to address the problem. Firstly, ensure that the patient is receiving 100% oxygen. If this is already the case, start to administer PEEP.
- If 'YES', then one can start to wean the patient to a FiO_2 of 0.5 (50%) or less.

The second parameter that needs attention and possible intervention is the patient's peak inspiratory pressure (PIP). Is the PIP 30 cm H_2O or less?

- If 'NO', reduce the tidal volume (V_T) and simultaneously increase the breathing frequency in order to maintain the minute volume (V_M). For example, a frequency of 10 with a V_T of 500 ml has the same V_M as a frequency of 15 with a V_T of 333 ml, namely V_M = 5 litres. The PIP generated by the V_T of 333ml is, however, much less than that of the V_T of 500ml.
- If 'YES', no further steps need to be taken.

CONCLUSION

Mechanical ventilation of an injured patient in the operational theatre should not prove to be a complicated and unsustainable procedure. The use of general guidelines to help the inexperienced health care professional could help improve the quality of care, improve patient outcome and reduce mortality.

Knowing the make and the capabilities of the available equipment and regular practice would also be beneficial to enhance the confidence of the health care professional as well as the patient outcome.

The availability of compressed oxygen and the logistical maintenance of an adequate reserve on the battlefield and resuscitation post are not plausible. It is thus advisable that the ventilator that functions on an internal compressor be used during these conditions. The pressure-driven ventilator is more advantageous at the field hospital setting where logistical support is available.

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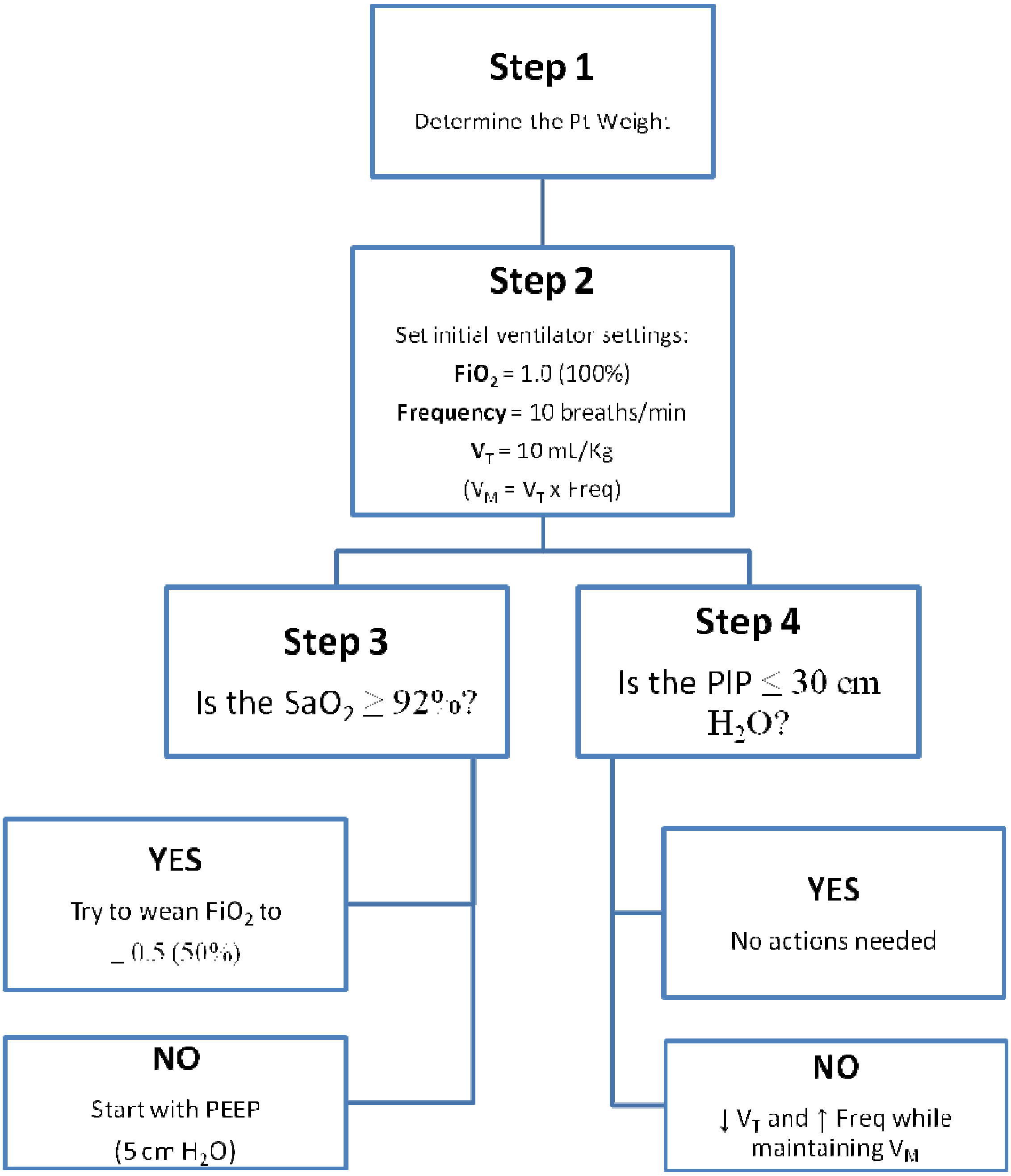

Diagram 1: Basic Mechanical Ventilation in the Operational Theatre

Haemostatic Technologies to Control Bleeding on the Battlefield

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ABSTRACT

Haemorrhage remains the most common cause of preventable mortality on the battlefield. Basic measures that could be used by everyone to control bleeding which include local pressure, adding a dressing of some sort (bomb bandage, pressure dressing, etc), applying pressure to pressure points and elevation of a limb are highlighted. This is substituted by the development of the so-called haemostatic dressings. These dressings stimulate clotting and can be used in areas where basic measures or a tourniquet is inappropriate or cannot be used. These products have been tested extensively for use with the military in operational situations. Different haemostatic agents are discussed indicating the various physiological mechanisms utilised to control bleeding.

Tourniquets were used extensively in previous wars and have again been proven to save lives if used correctly, but can be dangerous if used incorrectly.

The article demonstrates that effective haemostatic dressings available on the market can control bleeding from most wounds, and some can also prevent infection.

INTRODUCTION

Haemorrhage remains the most common cause of preventable mortality on the battlefield. Buddy aid was developed and taught to all troops to try and reduce this cause of mortality, but the activities remain very basic, namely local pressure to stop the bleeding, and adding a dressing of some sort (bomb bandage, pressure dressing, etc). When this is inadequate, applying pressure to pressure points and elevation of a limb can be added for control. Another adjunctive used on the battlefield is the tourniquet, which is very effective to stop bleeding if applied correctly, but training is necessary to achieve this. When the tourniquet is applied incorrectly, or not tight enough, it only constricts the venous return, leading to more bleeding. This is also only useful with extremity injuries, where a tourniquet can be applied.

A rather serious injury involving the groin (as was depicted in the movie Black Hawk Down) led to the development of the so-called haemostatic dressings. These stimulate clotting and can be used in areas where a tourniquet is inappropriate or cannot be used. These include QuikClot, TraumaDex (Arista), Celox, Hemcon, WoundStat, X-Sponge, etc. Most of these were developed in the USA on the request and funding of the US Military, and tested under strict scientific guidance and all seem to work in stopping the bleeding.

The experimental model (1,2,3,4,5) for testing all of these bandages is to create a severe groin injury in the pig where the groin is incised, transecting the femoral artery and vein totally or partially, allowing bleeding for a period of time (to simulate the operational situation) allowing the blood pressure to drop to around 40 mm Hg, then applying the dressing and resuscitating the animal to a mean blood pressure of around 60 mm Hg. Blood loss is measured before and after application of the dressing, and the end point of the study is survival for 3 hours,

which is the duration of the study. These were done by different investigators in different laboratories at different times, and were funded by different departments of the military. As can be expected, the results also differ, and the protocols were adjusted in time to accommodate some of the critiques on the model. One of the first models (1) where a complete transection of the vessels was done, the dressing with the best survival was Quikclot. This is dehydrated Zeolite granules that generate heat when exposed to fluids and blood, concentrating the clotting factors and platelets leading to haemostasis. The heat generated could also lead to haemostasis per se as this could stimulate the blood vessels to contract and stop bleeding (as was done ages ago with hot irons and hot oil poured into wounds). The Zeolite was later modified by making it less dehydrated to generate less heat (QuikClot 1st Response Advanced Clotting Sponge), but it seems as if the new product is not as potent to control bleeding as the original one, but it is safer, as the heat generated is much less and therefore the surrounding tissue damage also less.

HAEMOSTATIC AGENTS

QUIKCLOT

This was one of the earliest products passed for use by the US military, and has been utilized in operational circumstances in Iraq and Afghanistan. It consists of Zeolite, a volcanic rock substance, broken down to granules of around 2-3 mm, which is sterilized and dehydrated when packaged. It is extremely hygroscopic, and generates heat when it comes into contact with water and blood. The rationale for its effectiveness is that by absorbing water, the clotting factors and platelets are concentrated to give rise to a strong and effective clot to control the bleeding. The heat generated can reach 70 to 80 degrees C and can be damaging to the tissues in the vicinity of the injury. To reduce the heat generation the Zeolite dressing is modified by dehydrating it to a lesser degree (called QuikClot 1st Response) and also packaged in a bag (like a large tea bag) to

simplify the handling. It is not as effective in stopping the bleeding as the original product.

The latest product out of the QuikClot stable (Z-Medica, Newington, CT, USA) is the QuikClot combat gauze and QuikClot emergency dressing. These are gauze dressings impregnated with Kaolinite (a white alumina silicate clay material) that stimulates clotting by activating the clotting mechanism directly. The gauze dressing is applied directly over the bleeding wound with compression to control bleeding until the patient can be seen in an emergency department.

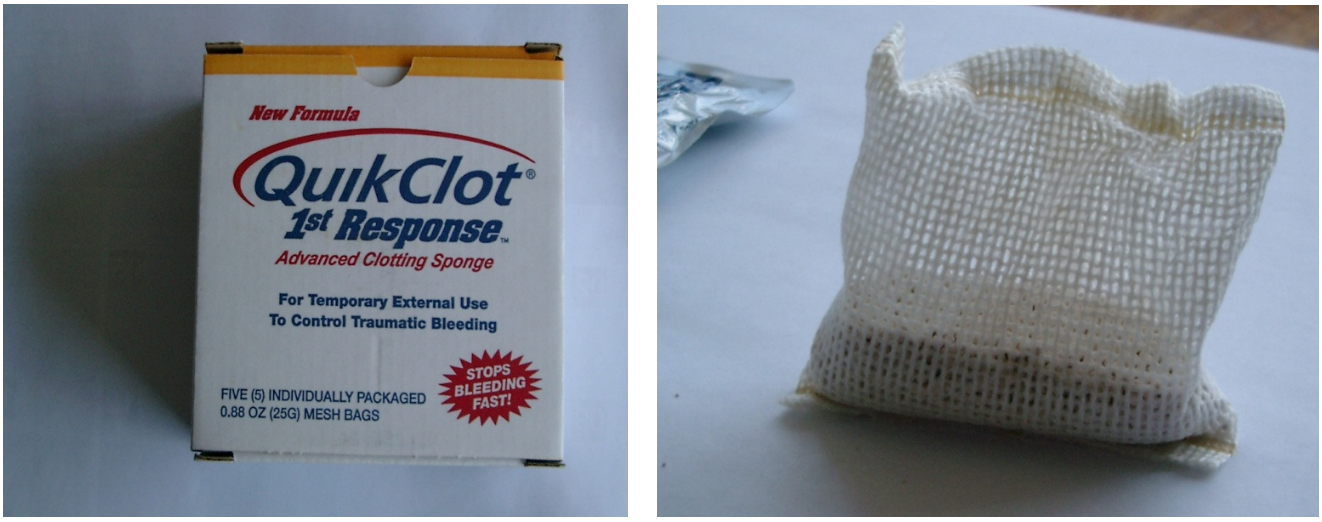

Figure 1: QuikClot First Response granules

TRAUMADEX and ARISTA

This product (Arista) has been on the market for a while as an adjunct to haemorrhage control during surgical operations. It consists of microporous polysaccharide hemispheres, which are small granules that absorb fluid from the bleeding site, concentrating the clotting factors to stimulate and accelerate the clotting cascade. It does not generate heat in the process. When the need for a pre-hospital haemorrhage control dressing or substance was identified, the product was marketed as TraumaDex. It is a white powder that can be poured directly into the wound. The price was also reduced, which led to the selective

use of the TraumaDex rather than Arista, after which the company (Medafor, Minneapolis, MN, USA) took TraumaDex off the market.

Figure 2: TraumaDex- Arista powder

HEMCON

This product has also been tested extensively (1,2,4,5) and is in use with the military in operational situations. Hemcon is a gauze dressing impregnated with chitosan, an extract of polysaccharide made from shrimp shells with haemostatic properties. This dressing becomes extremely adherent when in contact with blood, and this seals the wound and controls the bleeding. It can be placed on the wound, or stuffed into the wound. The mechanism of action includes platelet activation, vasoconstriction and interactions with red blood cells through ionic forces and cell surface proteins. A side effect that was found is the antibacterial properties (6) of the chitosan. It is effective against most of the common organisms found in war wounds, like MRSA, other Staphylococci, Streptococci,

and gram negatives like Pseudomonas, Acinetobacter, Serratia, Proteus, Enterobacter, Citrobacter, Moraxella, Stenotrophomonas, Salmonella, Shigella, etc. This makes it very effective in areas where evacuation is suboptimal, as the antibacterial effect prevents the development of infection in the wound, and second look and debridement can be postponed for a while. It is used extensively by the U S Army (7)during deployment. It is distributed by HemCon Inc, Portland, OR, USA.

Figure 3: HemCon Bandage

CELOX

This is another of the products available for haemorrhage control. It consists of chitosan, the same complex carbohydrate polymer extracted from the shells of crustaceans, and the mechanism of action is similar to HemCon. It stimulates the formation of a strong clot without generating any heat in the process. It is

marketed as a powder that can be poured into the wound, and then covered with a dressing or bandage. It is manufactured and distributed by SAM medical, Newport, OR, USA.

Figure 4: CELOX granules

My opinion is that the latter 2 products are the most effective and safest to use by our troops on deployment, as well as in the civilian pre-hospital environment.

TOURNIQUETS

Tourniquets have been used extensively in previous wars and also in the civilian sector. Tourniquets can save lives if used correctly, but can be dangerous if used by the untrained. If applied incorrectly, it can lead to increased bleeding when

only venous pressure is exceeded in stead of arterial pressure. It can also lead to limb loss if kept on too long and distal ischemia develops, and uncontrolled release can lead to renal failure when a large load of myoglobin is released from the ischemic muscle. The ideal tourniquet should be applicable with one hand and should be effective in controlling bleeding from any extremity, both large and small.

The popularity of tourniquets has varied through the ages and mostly finds popularity in conflicts as a way to control bleeding under fire, saving lives and buying time to evacuation of the injured. It is part of doctrine and training in most military forces (8,9,10,11,12) but mentioned as a last resort in the civilian pre-hospital scene as well as the ICRC (International Committee of the Red Cross) (13,14).

The current recommendations regarding the use of tourniquets are the following: (15, 16)

a. Try all other means stop haemorrhage, including direct pressure and pressure dressings.
b. If field conditions preclude other methods to control bleeding, use a wide tourniquet.
c. Use padding under the tourniquet, to avoid skin and soft tissue damage.
d. When applying a tourniquet, avoid the impulse “to do it partly”, because it should be fully applied, with high enough pressure to completely occlude arteries and arterial bleeding.
e. Record in an obvious place (eg forehead) on the patient that a tourniquet is in place, and the time it was applied.
f. Ensure that others along the chain of evacuation know that a tourniquet has been applied.
g. Avoid covering up a tourniquet in an unconscious patient.
h. Remove the tourniquet at the very first opportunity, preferably under surgical control.

Tourniquets come in a variety of forms and prices, and were previously evaluated (17, 18, 19). The TK4 tourniquet is a simple 6 cm wide rubber band with a metal hook that can be applied with one hand to control bleeding. A more complex (and expensive) type is the MAT (Mechanical Advantage Tourniquet), with a ratchet type mechanism to tighten the strap. In between is the CAT (combat application tourniquet) with a windlass to wind the strap to the right pressure to control the bleeding. This can also be applied and tightened with one hand.

Figure 5: TK4 Tourniquet

The TK 4 tourniquet is the one currently in use by our troops and medics while the CAT is available in some pre-hospital situations, special forces and the USA military.

Fig 6: CAT (Combat Application Tourniquet)

TORSO WOUNDS

All the above techniques are applicable to extremity wounds encountered on the battlefield. The torso can be (partially) protected by body armour, but some areas are still exposed and can lead to injury by penetration. These body wounds cannot be managed with superficial measures and still need surgery (and sometimes emergency surgery) to control the bleeding from a chest wound with injury to lung or blood vessels in the chest, or from an intra-abdominal organ injury (8,9,11,12).

HIFU (HIGH INTENSITY FOCUSED ULTRASOUND)

Ultrasound has been in use in medicine for a few decades, mostly in a diagnostic field. The transducer (or probe) sends a low frequency sound wave that gets reflected back from different organs, creating an image. When this sound wave is focused and intensified, it generates heat in a very small area, and this can

control the bleeding in that area by tissue coagulation. Injuries in blood vessels (20) and solid organs like spleen (21) and liver (22) have been sealed with HiFU under experimental conditions. If this process can be refined, theoretically injuries to the torso can be treated percutaneously with HiFU, without having to operate on patients under emergency conditions. One problem currently is to integrate the diagnostic and therapeutic transducers into one piece of equipment that can be used commercially, as it is very important to be able to see where the injury is and to focus the high intensity beam on the correct area of bleeding to be able to control it. This technology, however, is still some time off in the future.

CONCLUSION

Prevention of injury is still the best measure to control bleeding. If a soldier does get injured, there are very effective dressings available on the market that can control the bleeding from most wounds, and some can also prevent infection. Wounds to the body or torso still need emergency surgery for control of bleeding, but some developments are taking place that may in future be applicable in the battlefield. HiFU has some exciting applications, if the transducers can be modified to be user friendly under operational circumstances.

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Vehicle Extrication on the Battlefield

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ABSTRACT

Battlefield extrication can be defined as utilising the sequence of standard vehicle extrication to remove a life salvageable casualty from a battle vehicle in battlefield conditions.

This requires adapting the principles of extrication to achieve effective extrication from an armoured vehicle using tools and equipment not primarily meant for extrication in a hostile enemy environment during

mobile warfare. Where in standard extrication procedures the vehicle is considered expendable, the vehicle in battlefield extrication is a weapon platform that needs to be optimally conserved. The material used for the construction of battle vehicles makes the use of standard cutting and spreading techniques and tools inappropriate.

This article will apply the sequence of extrication to battlefield circumstances and summarise the recommended techniques for the main battle vehicles utilised by the South African National Defence Force.

INTRODUCTION

The mobility of modern warfare stems from the use of various types of battle vehicles to serve as weapon platforms, to transport soldiers and protect crew through armour and other designs. These vehicles, however, hold unique challenges when extricating casualties if it has been involved in an incident causing the entrapment of casualties.

Extrication is defined as the safe and efficient freeing of persons from entrapment in land-based vehicles of all types(1). This concept is critically important on the battlefield where casualties can be trapped in any of the various battlefield vehicles due to numerous reasons. The most obvious is the destruction of the inner structures of a battle vehicle due to an explosion caused by various forms of explosive devices inside the vehicle. Further causes include the destruction of the structure of the vehicle by the energy transfer from an external explosive device such as an improvised explosive device (IED) positioned on the roadside and detonated in the close vicinity of the vehicle. However, vehicle crashes and incidents such as a roll-over from high ground can all cause entrapment of casualties inside a battle vehicle.

Although explosive device incidents within the close confines of a battle vehicle are often fatal, life casualties may survive and need to be extricated as soon as possible. Extricating the bodies of fatally injured crew may also entail extrication.

An integral part of extrication is the disentanglement of the casualty from his or her entrapment by using various extrication techniques and equipment. Disentanglement is defined as that part of vehicle extrication that relates to the removal and/or manipulation of vehicle components to allow a properly packaged victim to be removed from the vehicle1). Sometimes referred to as "*removing the vehicle from the victim*"(1). It is this aspect of extrication that holds serious challenges for the rescuer on the battlefield.

BATTLEFIELD EXTRICATION

The basic sequence of vehicle extrication or rescue is summarised by various authors using different terminology, but, if consolidated(1)(2),it can be summarised asfollows:

- Size-up of the scene;
- Hazard control;
- Vehicle stabilisation;
- Initial and sustained patient access;
- Disentanglement;
- Patient packaging;
- Extrication;
- Patient transport; and
- Scene termination.

If this chronological process is analysed, the challenges of battlefield extrication become apparent.

The South African Army uses various types of vehicles as weapon platforms, transport, protection and support vehicles in landward defence warfare. For the purpose of this article, only the basic armour platforms will be discussed since the transport vehicles are fairly standard heavy trucks used in a unique role.

SCENE SIZE-UP

Scene size-up is described by Moore(2) as an information gathering activity through which responders survey and assess the overall emergency scene. A circle survey is described as the resulting determination of an extrication strategy to initiate the necessary measures to handle the situation. On the battlefield this process is often initiated by a command request for support elements to move forward in the battle configuration to support a specific vehicle. This radio message is often very vague, merely indicating that a vehicle with a specific call sign has been shot out.

The response is three-fold: firstly, all-round defence is established, then a medical support element moves forward and a technical support element is called forward. Because of battle configuration, the medical section is normally fairly close and can reach the scene within a short time span, while the technical support element lies further back and takes some time to reach the scene. This will, however, totally depend on the battle situation. If the target is not secure, reaction will need to be held back until own forces had fought through to the objective, after which the two support elements can move forward to manage the scene.

On arrival, scene size-up can only start when all-round defence is in place, which is normally the deployment of infantry elements in a semi-circle around the scene. On approaching the battle vehicle, its own weapon systems are the immediate threat. Control over these systems may not be functional because internal destruction may result in the uncontrolled firing of a main weapon such as a

canon. For this reason, approaches must be from behind and out of the firing range of the weapon systems. The survey can then be executed in a semi-circle only in order not to cross the firing range of the weapon. This may be jeopardised by secondary weapons pointing in alternative directions, further limiting the “circle survey”.

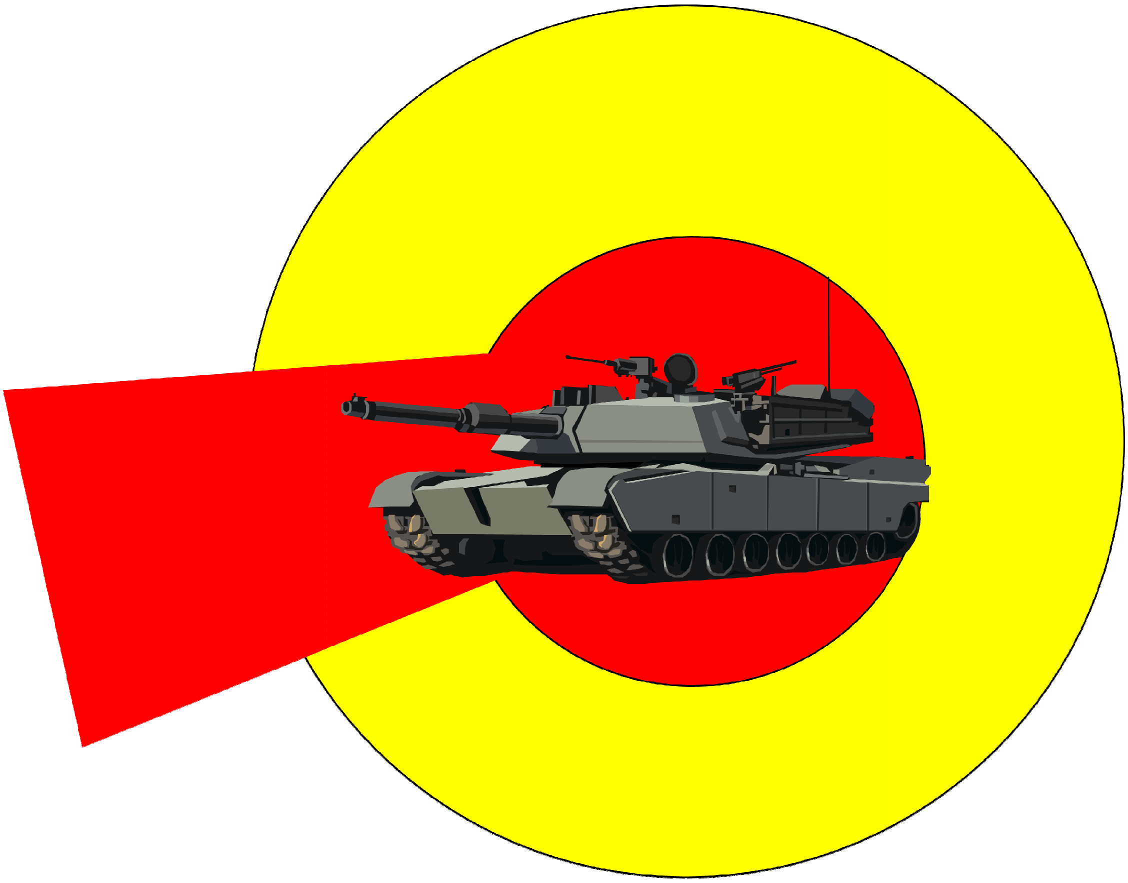

Fig 1: Scene Size-Up indicating the Danger Area during the Circle Survey in line with the Weapon Systems (Note: This is only a diagrammatical representation and additional danger areas may exist due to secondary weapon systems)

HAZARD CONTROL

Hazard control on the standard extrication scene includes, amongst others, identifying hazardous material, risks and unstable structures, and activating the necessary response such as the fire-brigade. In analysing hazards in a battlefield scene, this is not that simple. As already highlighted, the uncontrolled firing of weapons is a big threat, but sudden enemy actions may hold a similar risk. Unexploded ammunition in the vehicle holds a further challenge besides the standard hazards of leaking fuel and fire risks. The responders are totally dependent on the soldiers of the element involved to deactivate or safeguard weapon systems before attempting to manage the scene.

The risk of a sudden offensive action by the enemy must not be under estimated. Enemy elements fire at anything that moves on the battlefield, so a rescuer becomes an automatic target not withstanding all Conventions(3) protecting medical personnel. It is not realistic to expect the enemy to recognise a 15 cm diameter red cross armband at a kilometre distance as a sign of protection. Therefore, parking vehicles on a battlefield scene as a protective shield against enemy fire is just as important as parking the ambulance as a shield against oncoming traffic on a standard freeway scene. The use of brightly coloured reflective garments, neon colour cervical collars and day-glow orange head-blocks is not a warning tool as in civilian extrication, but becomes a target for a sniper in the battlefield situation.

Managing risks such as leaking fuel and possible fire is limited to pre-positioning of dry power extinguishers from the support vehicles in strategic positions and using sand to cover fuel. It is clear that a second hit by an explosive round from the enemy in this situation may wipe out the total responder group.

VEHICLE STABILISATION

Stabilising the damaged vehicle is aimed at preventing any sudden and unexpected movement of the vehicle(1). In standard extrication this entails cribbing and shoring the vehicle to prevent any movement during extrication.

Although it may be considered that a battle tank or armoured car is a very stable vehicle, this may not be the case. The vehicle may have been thrown onto its side Due to a roadside explosion, while a heavy battle vehicle travelling over uneven ground may slide or even roll-over into very unstable positions. Stabilising a 56 000 kg battle tank hovering over the side of a bridge or a 17 000 kg Ratel on its side is a challenge.

Fig 2: Unstable Battle Vehicle (**Picture:** xmb.stuffucanuse.com/xmb/viewthread.php?tid=3591)

There is no standard stabilisation equipment available on the battlefield to execute the task, and cribbing is not part of the standard set of battlefield equipment. Stabilisation can only be achieved by using the equipment on the standard recovery vehicle as well as the other battle vehicles. A few basic chocks are available as base blocks used under hydraulic jacks. Rescuers must therefore improvise using bottle-type hydraulic jacks and base blocks to try and achieve stabilisation. Additionally, the winch system and cables of a recovery vehicle can be used to partially stabilise a battle vehicle, taking all safety elements of cables under load into account. Anchor points may be extremely limited, especially on the savannah or desert battle terrain. The best way of anchoring an unstable heavy battle vehicle is often to attach it to a second similar or bigger battle vehicle to partially stabilise it, for example, to use a tank to anchor an unstable tank. The use of a chain saw (which is part of the standard recovery vehicle's equipment) in an applicable terrain to fell trees for cribbing is an option. As the functionality of the battle vehicle as a weapon platform needs to be preserved, standard drills such as to deflate the tyres to settle the vehicle on cribbing, are not recommended as it will jeopardise the vehicle's capability to move once the casualties have been removed and an enemy counter-action occurs. This requires the training of Technical Support Personnel in vehicle stabilisation and vehicle safety.

As soon as basic stabilisation has been achieved, and considering the weapon systems, access to the vehicle must be obtained.

INITIAL AND SUSTAINED PATIENT ACCESS

Gaining initial access to a standard vehicle is normally achieved with controlled glass removal after using a standard spring-loaded punch. On the battlefield, gaining vehicle access is limited to using the available hatches, as it is impossible to gain access through armoured steel or armour-plated glass using standard tools available on the battlefield. However, hatches are often secured,

locked from the inside, or jammed by the incident providing a serious challenge. Most hatches of battlefield vehicles can be opened using a size 14 Allen key, which can be obtained from any other battle vehicle on scene. If the mechanism is however jammed or the specific vehicle is not equipped with this capability, force is required. Most recovery vehicles carry a thermal cutting device, which is capable of cutting the hinges of the hatch or door. This is, however, a time consuming process requiring all applicable fire precautions. Most battle vehicles also carry a crowbar on an external mounting that can be used to force the hatches open. Emphasis is placed on the use of these tools on the weak points such as hatch locks rather than trying to force hinges.

Fig 3: Gaining Access to an Battle Vehicle

As soon as access is achieved, airing the vehicle from all harmful gases is a critical step. Opening the hatches, however, also provides oxygen to any smouldering fires inside the vehicle that may have catastrophic consequences. There is no easy solution to these challenges, and often requires simultaneous

fire fighting with the opening of the hatch. If ordnance explodes at that moment, it may kill all rescuers in the close proximity.

Rescuers must stand back to allow fellow soldiers of the element to deactivate or safeguard weapon systems before any rescue interventions.

As soon as safe access is achieved, sustained patient access must be achieved by opening all accessible hatches followed by a secondary size-up to determine the number, position and condition of crew members in the vehicle. As medical staff are often not orientated to the exact number and position of crew in all battle vehicles, using expertise from the army element on scene to identify all compartments of the vehicle where a crew member may be trapped is critical.

A complete check to identify the number of crew members, identify their condition through a primary survey, and then to allocate a triage priority will guide the disentanglement process. The Triage Sieve Method will be applied in this situation.

DISENTANGLEMENT

The primary survey is followed by a secondary survey to determine entrapment of the casualty. In standard vehicle extrication this entails inline cervical immobilisation, basic stabilisation, and then manipulating or removal of all vehicle structures that may obstruct extrication.

The battle vehicle is however a total different scene. First and foremost, the battle vehicle, for example, a tank, is a weapon system which is utilised in defence of a position or to attack an objective. In this role it is a valuable piece of equipment which must be preserved as far as possible and repaired as soon as possible. This is specifically applicable to the partially or lightly damaged battle vehicle. In the standard vehicle extrication the vehicle is seen as “expendable”

and is cut away from the casualty. In the battle vehicle the integrity of the vehicle is preserved as far as possible to ensure that it can go on fighting as soon as possible. Disentanglement in the battlefield scenario is therefore focussed on safely manipulating the casualty to remove the casualty from his/her entrapment, while preserving the integrity of the battle vehicle as far as possible.

The construction and interior of the battle vehicle also make it nearly impossible to use the standard vehicle extrication disentanglement approach. The construction is rigid with heavy steel constructions and extremely limited space. It is, for example, impossible to remove any structures around a tank driver due to limited space and thickness of the steel structures.

In-line spinal immobilisation is a standard first step in vehicle extrication. The risk for spinal damage is caused by the kinematics of trauma in a vehicle crash. The kinematics is directly related to the energy of the crash. The law of conservation of energy states that energy cannot be created or destroyed but can be changed in form. The implication of this law is that during a vehicle crash the energy of motion is dissipated by the bending of the frame and other parts of the vehicle. The remaining energy is transferred to the occupants and their internal organs(4). It is these forces that result in the blunt trauma in a vehicle crash. In the battle vehicle involved in an incident, the minimum energy is absorbed by the frame of the battle vehicle as there are very few structures that would bend resulting in most of the energy being transferred to the crew inside. If it is taken into account that most battle vehicles have very little restrains or safety harnesses for crew, this should then result in serious blunt injuries, including possible cervical damage. If this argument is followed, in-line spinal immobilisation should be a standard immediate action after gaining access to a casualty in a battle vehicle. The requirement for spinal immobilisation needs to be analysed in more detail.

KINEMATICS OF TRAUMA IN BATTLE VEHICLES

It is not possible to address the total spectrum of physical forces involved in battlefield interaction such as kinetic energy, momentum and transfer of energy (explosions) within the context of a journal article. To demonstrate the impact, only kinetic energy will be analysed.

Kinetic energy equals one-half the mass times the velocity squared4). If a standard sedan vehicle of 1090 kg is travelling at 120 km per hour, the kinetic energy involved would therefore be:

$$
\begin{aligned}
\text{KE of Sedan Car} &= \tfrac{1}{2}mv^2 \\
&= \tfrac{1}{2}(1090)(432)^2 \\
&= 101710080\text{J} \\
&= 101710.08\text{kJ}
\end{aligned}
$$

If this same calculation is done for an Olifant tank with a mass of 56 000 kg travelling at 30km/hour in the veldt, the kinetic energy can be estimated.

$$
\begin{aligned}
\text{KE of Olifant Tank} &= \tfrac{1}{2}mv^2 \\
&= \tfrac{1}{2}(56000)(108)^2 \\
&= 326592000\text{J} \\
&= 326592\text{kJ}
\end{aligned}
$$

If the kinetic energy is compared Car:Tank

$$
\begin{aligned}
&= 101710{,}08 : 326592 \\
&= 1:3.21
\end{aligned}
$$

If the principle that the structure of the tank absorbs the minimum of kinetic energy during impact is valid, a crew member in a tank is subjected to 3.21 times the kinetic energy that is present in a standard sedan vehicle crash.

The impact of the transfer of energy to the human body resulting in blunt trauma is caused by two forces on the body, namely shear and compression(4). Shear is the result of one organ, structure or part thereof changing speed faster than another organ, structure or part thereof. Compression is the result of an organ, structure or part thereof being directly squeezed between other organs, structures or part thereof. It is these two forces that are of importance when analysing the kinematics of trauma to determine the most appropriate and safe way to disentangle a casualty from a battle vehicle.

The analysis of the various effects of kinematics and mechanisms of injury in the various battle vehicles falls outside the scope of this paper. To conclude, it must be accepted that the forces involved can cause serious shear and compression injuries in a crew of any battle vehicle, requiring optimum stabilisation and packaging prior to extrication.

As soon as the weapon system is secured and ordnance declared safe, the combat medic should access the vehicle through the access hatches and crawl as close as possible to each casualty. Casualties able to free themselves and without obvious injuries must be encouraged to extricate themselves from the vehicle. Trapped casualties must be assessed to determine what part of the body is trapped by what structures. If the crew seat is adjustable, as in the Ratel driver position, the seat can be manipulated in an effort to free a casualty. Wearing leather protective gloves, palpate each casualty from head to toe to identify entrapment. This is not possible for an Olifant tank driver, and difficult for the Rooikat driver. In other battle vehicles and other crew positions in a tank and Rooikat this is however possible, on condition all hatches are accessible. Where possible, limbs are manipulated to free them from entrapment.

Often driver entrapment is caused by the driver's boots that become trapped among the pedals. By cutting the laces of the boots with a seatbelt cutter, the driver's feet can be freed from the trapped boots.

Crew members are often trapped by their webbing or uniform (tank overall) which can become entangled in an internal structure. Undoing the casualty's webbing is often sufficient to disentangle the crew member; thereby removing casualty from his/her entangled webbing. Palpate specifically to determine if uniform components are not just hooked onto a structure.

PACKAGING

Packaging is at most times executed concurrently with disentanglement. Basic principles for packaging are applied. Immobilise where possible prior to movement is the basic concept if emergency extrication is not indicated.

In line cervical immobilisation, as discussed above, should be considered, taking the kinematics of the specific incident (mechanism of injury) into account. If the battle vehicle was involved in a frontal impact incident, the resulting shear forces (flexion and extension) may cause cervical trauma. However, due to the weight of the vehicle, a rear or lateral impact has less possibility for shear forces. If possible, inline immobilisation and a rigid cervical collar should be considered. The use of an extrication device such as a Kendrick is possible in the Ratel and Rooikat scenarios and should be used except in emergency extrication actions. In the Olifant Tank evolution, however, this is not possible. In extricating the tank driver, application of a cervical collar can be attempted, but it is not possible to apply any other immobilisation devices.

Fig 4: Optimally immobilising (packaging) a casualty prior to Extricating. (Note: It is seldom possible to apply an extricating device in the confined space of the Battle Vehicle and often a rigid cervical collar and manual in-line immobilisation is the optimal approach.)

EXTRICATION

Extricating is the final step to remove the casualty from the vehicle. In each battle vehicle, the most appropriate route for each crew member must be evaluated, however, often casualties are thrown from their seats into alternative positions in the vehicle by the impact or explosion. Often all the hatches/doors are not accessible and alternative egress routes must be used.

In theory casualties should be extricated in triage priority as the most serious need to be removed first to enable medical staff to optimally resuscitate the casualty outside the confines of the vehicle. This, however, remains a theoretical ideal. Often, access to more serious casualties is obstructed by less injured and lightly trapped casualties. In such a situation, the less serious injured casualty

must be extricated first to enable rescuers to reach the other casualty(s), and to provide working space in the confines of the vehicle.

Due to the nature of battlefield extrication and the serious injuries possible, the calling forward of a military paramedic to assist with care and/or a forward medical team from the Level 1 Resuscitation Post(5) need to be considered.

Olifant Tank

Driver

The barrel/turret must ideally be moved to the ten past position to allow optimum access to the driver's hatch. No 1 Combat Medic must lie down on his/her stomach to the side of the hatch and reach into the driver's compartment to achieve inline immobilisation from the side. No 2 Combat Medic, in a similar position from the front, can then apply a cervical collar.

Standing over the hatch, facing backward, reach down and grip the driver by his/her crew handle situated on the back of his/her tank overall, and pull him/her vertically upward out of the compartment. As soon as the driver's torso is lifted out of the compartment, the second combat medic, against the turret and facing forward, places his/her arms underneath the driver's armpits and lifts him/her out of the compartment supporting him/her against his/her body. Support staff needs to position a stretcher on the longitude axes of the tank, holding it at the height of the hatch. The driver is then slipped feet first onto the stretcher.

Fig 5: Extricating the Driver from a Olifant Tank

If the driver's hatch is inaccessible, the compartment can be accessed from the crew compartment by lowering the driver's chair and dropping the backrest of the chair thus providing partial access to the driver. If the driver is unconscious, it is nearly impossible to extricate him/her via this escape route.

Tank commander, gunner and loader

All tank crew are accessible in the main crew compartment. Although space is very limited, it is possible to achieve inline cervical immobilisation and to apply a cervical collar. With No 1 Combat Medic supporting the casualty inside and No 2 positioned over the hatch and pulling the casualty upward by the crew handle of his/her tank overall. As soon as the torso is lifted from the hatch, the casualty is again supported from under the armpits and lifted from the tank. The easiest is to carry the casualty to the back of the tank and to place him/her on a stretcher. Heat from the engine can be a hazard.

An emergency hatch is positioned under the tank and can be opened from the outside. Crawling in through this hatch, extrication through this hatch will be a

basic push and pull action with no possibility of any immobilisation. In the unlikely event of a tank overturning, this is the only accessible hatch.

Rooikat Armoured Car

Driver

Turning the barrel to the ten-past position provides optimum space to access the driver's hatch. The driver's compartment is more spacious than the tank driver's compartment, but it is still challenging to extricate the driver. Inline immobilisation and cervical collar application can be achieved from the external position. A similar drill to the tank extrication needs to be used.

Commander, gunner and loader

The three crew members are accommodated in the main crew compartment. Extrication is again upward through the hatches. Placing a stretcher on the grit over the engine makes it possible to place the casualty on a stretcher and then to lower the stretcher to the ground. The risk that this area may be very hot due to the engine needs to be assessed before it is used.

An emergency side hatch is positioned on the side of the vehicle between wheel two and three. This hatch can be used if the main hatches are inaccessible. To be able to extricate casualties through this hatch, the turret needs to be in the quarter-two position. The Allen key to open the hatch is mounted just above the hatch. After opening the hatch, the ammunition box needs to be removed as well as the round in the clamps in front of the hatch. Moving the casualty out through this hatch is challenging due to various structures that have to be negotiated. Moving the turret back to the twelve -o'clock position allows the optimum space to move a casualty through this hatch.

Fig 6: Extricating a Casualty through the Side Hatch of a Rooikat Armour Vehicle

Ratel Infantry Vehicle

The Ratel is the most spacious of the battle vehicles in use. With a crew of three and carrying 9 infantry soldiers travelling at a speed of 80 km/hour it is also the vehicle with the biggest risk for extrication.

<u>Driver</u>

The driver’s compartment is accessible from the main compartment or through a hatch above the driver. It is possible to package the driver using standard extrication devices such as the Kendrick. The easiest way to extricate the driver is again upwards through the hatch and then sliding the casualty onto a stretcher on the “bonnet” section of the Ratel.

<u>Gunner and Commander</u>

Extricating these crew members upwards through the hatch is possible, it is, however, also possible to extricate them through the side door. If extricated

through the hatches, the casualty is placed on a stretcher on top of the vehicle and then lowered to the ground.

Infantry Crew

These members can be extricated without much trouble through the side doors, rear door or any of the roof hatches. Immobilisation is possible prior to extrication. It must be emphasised that, as no safety harnesses are used, head and neck injuries are serious possibilities.

G6 Gun

One of the most challenging vehicles to extricate casualties from is the G6 gun due to the height of the crew compartment door and the depth inside the crew compartment.

The only door to the crew compartment is very narrow and positioned to the side of the compartment. Casualties can be stabilised and immobilised using extrication devices in the crew compartment, but they need to be man-handled through the door. Adequate space is available on the landing outside the door to position a spine board. The casualty can therefore be slid out of the crew compartment onto a spine board.

Due to the height of this section of the vehicle it is impossible to safely lower the spine board from this position to the ground. The most appropriate method is to back an Mfezi ambulance against the G6-gun and then to slide the spine board over to the top stretcher of the Mfezi.

Fig 7: Transferring a Stretcher Casualty from the G-6 Gun to the Mfezi Ambulance

POSITIONING CASUALTIES AFTER EXTRICATION

It is a standard Army drill to position all casualties next to the left front wheel/track of the vehicle. This is not practical for the G6 gun due to the drill to move the casualty directly into the ambulance.

Taking enemy positions into account, this drill can be applied and stabilisation then carried out prior to evacuation.

Fig 8: Military Paramedic Establishing a Stabilisation Point at the Left Front of a Battle Vehicle

EMERGENCY EXTRICATION

The unique battlefield situation, enemy action or risks of exploding ordnance may require the emergency extrication of casualties from a vehicle. If the commander identifies a risk, he/she may order an emergency extrication. In this drill every casualty that is not trapped is dragged out at best speed. In the Armour vehicles this will entail using the crew handle on the tank overall and dragging the casualty out by force. If time and situation permit, an effort can be made to free partially trap casualties and drag them to safety. Trapped casualties will however have to be sacrificed or left to the enemy in an emergency situation.

Taking the weight and construction of battle vehicles into account, the risk exists that a trapped casualty could not be freed from his/her entrapment and that an

emergency amputation may be required. If this scenario occurs, the damage control surgery team from the Level 1 Medical Post must be sent forward to execute the amputation. This requires basic anaesthesia skills and basic surgical capabilities. In ideal situations, the Orthopaedic surgeon from the Level 2 Field Hospital should be requested to execute the amputation(5).

THE ROLL-OVER BATTLE VEHICLE EVOLUTION

Although heavy track vehicles such as tanks are very stable platforms, the risk does exist that such a vehicle may slide down an embankment, fall into a tank-trap or roll-over due to a steep incline. If the limited vision of the tank-driver through his scopes is taken into account, this scenario is a real possibility. Many extrication experts have debated this scenario at various forums. If the size and position of the emergency hatch underneath the tank is taken into account, a near impossible extrication scenario exists. It has happened in history that the only solution was to upright the tank with the crew inside, open the hatches and then to try and do what is possible for the surviving crew.

PATIENT TRANSPORTATION

Taking the battlefield situation into account, all casualties are assembled at the front left corner of the vehicle. A stabilisation point is established at this position and casualties re-triaged and stabilised. If this position is exposed to enemy fire, an alternative, more secure position must be identified. Preferably, the Sort method of triage should now be utilised to determine evacuation priorities. Taking the compression forces of the mechanism of injury into account, internal bleeding, especially thoracic and abdominal, need to be a major concern, as these non-compressible bleeding will require damage control surgery, time must not be

wasted at the stabilisation point prior to evacuation. The danger of starting re-bleeding if the blood pressure is dramatically improved through intravenous fluid infusion needs to be considered, with the guideline to maintain a palpable radial pulse.

If a casualty is trapped under an armoured vehicle, the risk of traumatic asphyxia exists. In lifting the vehicle this risk should be considered with oxygen administration and judicious ventilation support provided4).

CONCLUSION

Battlefield extrication is a complex and ill described activity. The kinetic energy created by battle vehicles hold the risk for serious shear and compression forces to cause serious injuries. However, standard extrication processes cannot be directly applied in battle. This requires using the standard steps of an extrication evolution but adapting it for the circumstances. Extrication tools are limited to the standard recovery vehicle and the tools on the battle vehicle, while the paradigm is for optimal conservation of the partially damaged battle vehicle. Armoured steel, weight, space, unexploded ordnance and weapon systems all jeopardise the actions. Stabilising the battle vehicle requires innovative thinking and optimum use of available resources.

Different battle vehicles require unique evolutions to gain access, disentangle, package and extricate casualties from the various positions in the vehicle.

As the Military Health Service, according to its doctrine and philosophy, accepts responsibility for care from point of injury, the role of the combat medic to extricate casualties cannot be negated. In this role he or she is, however, heavily dependent on the technical recovery staff's and the fighting elements' expertise to extricate casualties successfully. The combat medic however remains

responsible to guide the extrication process from a functional (medical) perspective, and to ensure that optimum care is provided.

Within the battlefield situation, the risk for emergency situations necessitating emergency scoop and run operations always exist and the frightening possibility of having to sacrifice a trapped casualty during enemy action or a threatening explosion.

The ability to extricate casualties in battle vehicles is based on good basic knowledge of the science of extrication and proper training to apply and improvise those skills in battlefield conditions.

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Health Care Management of Radiation Casualties

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ABSTRACT

All humans are exposed to certain levels of naturally occurring radiation without any harm. Ionizing radiation is radiation that causes ionisation of atoms and is potentially harmful to humans.

The effects of ionising radiation on humans are the result of changes to the DNA and other sub-cellular structures with resultant cellular damage that may be repairable or may result in cellular death. Radiation effects are determined by dose rates, time of exposure and distance from the source of radiation.

High dose rates may lead to Acute Radiation syndrome, which consists of four elements, namely haematopoietic syndrome with depression of blood forming organs, gastrointestinal syndrome affecting the gastrointestinal system, neurovascular syndrome affecting the brain and muscles, and cutaneous syndrome affecting the skin.

Treatment of radiation patients is primarily supportive by some additional specialised procedures such as stem cell transplantation when required.

The health care management of patients exposed to radiation is complex and demands a well coordinated multidisciplinary effort. Therefore, it is necessary that health care personnel have some knowledge of the effects and management of radiation injury.

The fact that the effects of radiation occur after a time period indicates that the primary responsibility of emergency workers at the incident is to determine the presence and levels of radiation through well

documented information and monitoring, while treatment will primarily occur at hospital level.

INTRODUCTION

All living creatures are exposed to certain levels of radiation (background radiation) that occurs naturally due to trace amounts of radioactive materials that occur everywhere; in the soil, building materials, food and drink, the air, our own bodies (muscles, bones, and tissue) and sea water. The earth is also subject to radiation from outer space called cosmic radiation. Background radiation must always be taken into account when radioactivity is measured.

Humanly produced radiation, such as X-rays, radiation for diagnostic procedures and cancer therapy, and small quantities of radioactive materials released into the environment from coal and nuclear power plants are also sources of radiation.

TERMINOLOGY

In order to have a clear understanding of all the aspects related to radiation, it is necessary that some concepts are described.

Atomic Structure

The atom is the basic unit of all matter. It consists of a nucleus around which one or more electrons circle. The nucleus consists of protons and neutrons. Electrons are negatively charged, protons are positive and neutrons have no charge. In most atoms there are an equal number of electrons and protons and, therefore they have no electrical charge (1,2).
Atoms combine to form molecules which are the building blocks of matter.

Ionisation

An ion is an atom that has an electrical charge due to an imbalance between the numbers of protons and electrons.

Ionisation is the process in which an atom or molecule is converted to an ion by adding or removing electrically charged particles (electrons or protons) from the atom or molecule (1, 2).

Radioactivity

Some natural elements are unstable; their nuclei tend to disintegrate with resultant release of energy in the form of radiation. This phenomenon is called radioactivity. Radioactive atoms are called radionuclides (1, 2).

Ionizing Radiation

The radioactive emissions listed above will increase the ability of any medium through which they pass to conduct an electrical current, in other words, they will ionise that medium. Therefore, the radiation caused by these emissions is called ionizing radiation (1).

In living tissue ionizing radiation causes damage to organic molecules and therefore, to living cells and tissues. In this regard DNA is of particular importance.

Non-Ionizing Radiation

Non-ionizing radiation does not have the amount of energy needed to ionize an atom with which it interacts.

Sources of non-ionizing radiation include sunlight, microwaves and infrared lights.

Radiation types

There are four known types of ionizing radiation:

a. <u>Alpha Radiation</u>. Alpha radiation is produced by alpha particles. Alpha particles are heavy, positively charged particles emitted by

large atoms of elements such as uranium and radium. They can only travel a short distance (2,5 – 4 cm) in the atmosphere and can be stopped completely by a sheet of paper or by the epidermis. However, if alpha-emitting materials are taken into the body, they will cause serious biological damage to living cells (1, 2).

b. Beta Radiation. Beta particles cause Beta radiation. Beta particlesare high-speed electrons. They can travel up to 3m through the air and are more penetrating than alpha particles. They can pass through up to around 1 cm of water, but are shielded by plastic safety glasses and thin metal sheeting such as aluminium. Beta particles pose an external and internal hazard to humans (1,2).

c. Gamma Rays. Gamma rays are not material particles, but energetic photons of invisible light. Depending on their energy, they can pass right through the human body, but can be stopped by thick walls of concrete or lead. Gamma rays pose external as well as internal hazards (1,2).

d. Neutrons. Neutrons are uncharged particles and do not produce ionisation directly, but their interaction with the atoms of matter can give rise to alpha, beta, gamma, or X-rays that then produce ionisation[2]. Neutrons have a long range, are relatively penetrating in tissue, but are shielded by hydrogenous materials such as water and paraffin.

EXPOSURE TO IONISING RADIATION

The factors influencing the effects of ionizing radiation are the dose of radiation the tissue receives, the duration of exposure as well as the distance from the source of radiation.

Exposure can be acute, prolonged or intermittent. It can occur alone or in combination with other injury.

Radiation Dose

The radiation dose that allows for different relative biological effects of the different types of radiation is called the equivalent dose and is measured in Sievert (Sv). Radiation doses are normally expressed in millisievert (mSv) or microsievert. The average radiation exposure due to natural background sources amounts to approximately 2.4 mSv a year.

Lower doses will only have effects after prolonged exposure, while acute effects may develop after short exposure to very high doses. Since long term exposure is more relevant for lower doses, such doses are usually defined in terms of exposure over time and are expressed in mSv/hour or mSv/annum.

RADIATION DOSE	BIOLOGICAL EFFECTS
2,4 mSv/a (approximately)	Normal background radiation.
< 100 mSv	No effects.
100 – 250 mSv	Minor blood effects possible after acute exposure.
1000 mSv	Exposure over time to reach this dose may cause cancer in the long–term.
3 000 mSv	Gastro-intestinal effects such as nausea and vomiting as well as decreased white cell count. Patients usually recover.
3 000 - 10 000 mSv	Severe radiation sickness. 50% mortality after 30 days.
>10 000 mSv	Death within a few weeks.

Table 1: The dose effects of ionising radiation (2, 3)

Duration of Exposure

A person has to be exposed to radiation for a certain period of time for negative effects to occur. The higher the dose the shorter the time period one can remain without effect under that specific dose rate.

There are guidelines and time indicators available that indicate safe time periods under specific radiation doses, so-called stay times. These tables are used as indicators during rescue operations due to the fact that there is not sufficiently complete protection against gamma radiation available. The stay time can be calculated as follows:

Stay time = Exposure limit/dose rate

Radiation Dose	**Stay time to receive dose**		
	10 mSv	**100 mSv**	**1 Sv**
0,01 mSv/h	6 weeks	1 year	-
1 mSv/h	10 hours	100 hours	6 weeks
10 mSv/h	1 hour	10 hours	100 hours
100 mSv/h	6 minutes	1 hour	10 hours
1 Sv	36 seconds	6 minutes	1 hour

Table 2: Examples of stay times (4)

Distance from Source

The radiation dose rate decreases with distance from the source of radiation according to the inverse square law. The dose rate at a source will decrease to ¼ of the original dose rate when distance is doubled and to 1/9 when the distance is trebled. Therefore, distance from the source of radiation plays an important role as a protection measure against radiation injury.

Routes of Entry

Radiation or radioactive materials can enter the body through inhalation, ingestion, absorption through the skin and through open wounds. Radiation will also affect the skin directly and, in many instances, the skin will show the first signs of radiation injury.

Types of Exposure

People can be exposed to radiation from sources external to the body, which may be to the body as a whole or only to parts of the body, or to internal sources due to inhalation, ingestion or absorption through open wounds after contamination with radioactive materials.

A patient with internal exposure or external exposure that is not related to contamination is not a source of radiation and does not pose a danger to health care personnel. However, patients that have been contaminated may pose a risk to others and need to be decontaminated.

BIOLOGICAL EFFECTS OF RADIATION

Ionising radiation affects atoms through ionisation. Therefore, biological effects are the result of ionisation of atoms in cellular structures. For low levels of radiation exposure over short time periods, the biological effects are so small that they may not be detected because the body has repair mechanisms against damage caused by radiation.
The effects of radiation can be direct or indirect.
Direct effects occur through direct interaction with the atoms of the DNA molecule or some or critical cellular elements with resultant cellular malfunction or death. The probability of this mechanism occurring is small due to the fact that the DNA molecules make up such a small part of the cellular structure.
The indirect effects due to interaction between the radiation and the cellular water are more probable. The radiation releases energy in the water which leads to the creation of unstable toxic, hyperoxide molecules such as Hydrogen Peroxide (H_2O_2). These molecules interact with others breaking chemical bonds and producing new chemical bonds and cross-linkage between macromolecules damaging molecules that regulate vital cell processes causing damage to sub-cellular structures. The cell can repair certain levels of cell damage caused by low doses of radiation, but at higher doses cell death will result from exposure. Damaged cells may still reproduce, but the daughter cells may be lacking in some critical components and they die or they mutate and reproduce. Such reproduction of mutated cells may become malignant tumours (5, 6, 7).

Actively producing cells are more sensitive to radiation than those that reproduce less actively. The blood forming cells (particularly Lymphocytes) are the most sensitive reproductive organs and gastrointestinal cells are less

sensitive followed by skin, while bone, teeth, muscle and nerve cells are the least sensitive.

The biological effects of radiation are divided into:

a. Acute Effects. Acute effects occur after exposure to high doses of radiation over a short period of time (minutes to hours). These effects tend to kill cells and damage tissue and organs if the dose is sufficiently high.

b. Chronic Effects. Chronic effects occur after long term exposure to low doses of radiation. The effects of low doses are on cellular level and, therefore, they do not cause immediate damage to tissue or organs. The effects may only become visible after many years (5 – 20 years). Since chronic effects of radiation fall outside the scope of this article, it will not be discussed in more detail.

Acute effects

High radiation doses can kill so many cells that tissue and organs are damaged immediately resulting in a whole body response called Acute Radiation syndrome. Approximately 134 plant workers and fire-fighters battling the fire at the Chernobyl power plant received high radiation doses (800 to 16,000 mSv) and suffered from acute radiation sickness. Of these, 28 died within the first three months from their radiation injuries (8).

The extent of the pathological effects of radiation vary from person to person and is dependent on factors such as the general health status of the individual before exposure and the medical care received after the exposure. However, it is estimated that 50% of a population exposed to 3 500 mSv – 5 000 mSv over a period ranging from a few minutes to a few hours would die within thirty days after receiving a dose to the whole body (LD50/30) (8).

Similar exposure of only parts of the body will likely lead to more localized effects, such as skin burns.

Acute Radiation Syndrome (ARS)

ARS occurs after exposure of the whole body or large parts of the body to a high radiation dose (>1 000 mSv) over a relatively short time period.

ARS consist of one or more of the following clinical syndromes: haematopoietic syndrome with depression of blood forming organs; gastrointestinal syndrome affecting the gastrointestinal system; neurovascular syndrome affecting the brain and muscles; and cutaneous syndrome affecting the skin.

Each syndrome consists of a prodromal phase, latent phase, manifest illness and recovery or death depending on the exposure dose rate.

The typical course of ARS involves an initial prodromal phase with non-specific symptoms such as nausea, vomiting, fatigue, malaise and loss of appetite. An early onset of symptoms in the absence of associated trauma suggests exposure to a large radiation dose (6).

The prodromal phase is followed by a latent phase in which the patient is relatively symptom free. The length of this phase varies with dose. The latent phase is the longest preceding the hematopoietic syndrome and may vary between 2 and 6 weeks. It is somewhat shorter prior to the gastrointestinal syndrome, duration of a few days to a week. It is the shortest of all preceding the neurovascular syndrome, lasting only a matter of hours. These times are variable and may be influenced by the presence of other disease or injury. Therefore, it is not practical to hospitalize all personnel suspected of having radiation injury early in the latent phase.

Clinical illness follows the latent phase. It is characterised by the clinical symptoms associated with the injured organ systems including anaemia, infection, bleeding, gastrointestinal symptoms and neurovascular symptoms.

Haematopoietic Syndrome

The primary element of this syndrome is bone marrow depression that leads to pansitopaenia. The first peripheral blood changes will become apparent within 24 hours after exposure. Lymphocytes will be depressed first, followed by other leukocytes and thrombocytes. The average time for the onset of bleeding, anaemia and decreased resistance to infection is 2 to 3 weeks and potentially lethal cases of bone marrow depression may occur 6 weeks after exposure. The most useful laboratory procedure to evaluate marrow depression is the peripheral blood count. A50% drop in lymphocytes within 24 hours indicates significant radiation injury. Early therapy should prevent nearly all deaths from marrow injury alone (6).

Gastrointestinal Syndrome

Radiation causes loss of intestinal crypts and breakdown of the mucosal barrier resulting in abdominal pain, diarrhoea, nausea and vomiting, and predisposes patients to infection. The gastrointestinal syndrome will almost always be accompanied by bone marrow suppression. The prodromal phase is characterised by nausea, vomiting, watery diarrhoea and cramps. Symptoms subside during the latent period. Manifest illness consists of vomiting, severe diarrhoea associated with high fever and systemic effects which may include malnutrition from malabsorption; bowel obstruction from ileus; dehydration, cardiovascular collapse, and electrolyte derangements from fluid shifts; anaemia from damage to the intestinal mucosa and microcirculation, and subsequent gastrointestinal bleeding; and sepsis and acute renal failure. Treatment consists primarily of fluid replacement and prevention of infection.(6, 9).

Neurovascular Syndrome

The neurovascular syndrome is associated only with very high acute doses of radiation (20–40 Sv) and its stages are compressed. The prodromal phase is characterised by disorientation, confusion, and prostration and may be accompanied by loss of balance and seizures. Physical examination may show papill-oedema, ataxia, and reduced or absent deep tendon and corneal reflexes. During the latent period, apparent improvement occurs for a few hours and is followed by severe manifest illness. Within 5 to 6 hours, watery

diarrhoea, respiratory distress, hyperpyrexia, and cardiovascular shock can occur with a steady deteriorating state of consciousness and eventual coma and death (6, 9).

Cutaneous Syndrome

Cutaneous injury usually occurs after partial body or local exposure depending on the dose. The epidermis, dermis and at times deep soft tissue and even underlying muscle may be affected in cases of exposure to high doses. Symptoms include erythema, pain, oedema, dry and wet desquamation, blistering, necrosis and gangrene. Oedema, which places the patient at risk for a compartment syndrome, may develop. Local skin injuries develop over weeks to months and are difficult to treat with standard methods(9, 8)

MEDICAL MANAGEMENT

The medical management of radiation and combined injuries can be divided into three stages: triage, emergency care, and definitive care. During triage, patients are prioritized and rendered immediate lifesaving care. Emergency care includes therapeutics and diagnostics necessary during the first 12 to 24 hours. Definitive care is rendered when final disposition and therapeutic regimens are established.

The most important aspect of emergency radiation exposure management is the recognition of such an incident and the determination of levels of exposure, type of exposure and the need for decontamination.

Actions when radiation injury is suspected

a. In individual cases, it is important to obtain as complete a history from the patient as possible. Information such as contact with any unknown or metallic object, similar symptoms amongst family members and knowledge about the mechanism of injury should be obtained.

b. If contamination is suspected, the patient must first be decontaminated, all other cases pose no threat and management should continue normally.

c. A full blood count should be done as soon as possible and should be repeated every 4 – 6 hours. A drop in absolute lymphocyte count will indicate recent exposure. Low total white cell and platelet counts will indicate exposure a few days to weeks earlier.

d. Although symptoms develop over time, the primary goal should be the evacuation of a radiation casualty prior to the onset of manifest illness.

Triage

Associated conventional injuries must always be treated first because radiation does not produce early life threatening symptoms. Therefore, the primary purpose of triage on the scene of injury is to sort patients according to conventional injuries or other non-radiation-related conditions.

The purpose of radiation-related triage is to:

a. Identify those that have been exposed to radiation;
b. Identify those that have not been exposed; and
c. Determine whether those exposed to radiation have been contaminated in order to decontaminate them.

The primary activities required for triage at this stage are proper history taking and monitoring for radiation. Patients with conventional injuries must be monitored and interviewed first to determine radiation status.

The next level of triage will be at hospital where the purpose is to:

a. Identify those who have been exposed to radiation and will definitely require further treatment;
b. Identify those who may have been exposed to low levels of radiation that might have an effect on their health. Those will mostly be long term effects; and
c. Identify those that might have been exposed, but the exposure would not have an effect on their health (10).

History, monitoring and full blood count are essential tools at this level as well as the presence of early symptoms of ARS. A full blood count should be done on all those exposed with follow-up tests as described previously. People in the third category must be followed up for a period to ensure that they have not been affected.

Definitive Treatment

Supportive treatment and management of symptoms are the most important elements of treatment of these patients. Supportive treatment includes the administration of antibiotics, antiemetic agents, anti-diarrhoeal agents, fluids, electrolytes, analgesic agents and topical burn creams.

Prevention of Infection

Prophylactic antibiotic therapy should be directed against gram-negative bacilli. In patients who do not have neutropenia therapy should be directed against specific infections while those with neutropenia should be treated with broad spectrum antibiotics (9, 10).

Nutrition should include an enteral hypercaloric diet, glutamine and sucralfate to protect the enteral mucosa, parenteral nutrition and fluid and electrolyte replacement as required(10).

Dermoprotector creams in the prodromal phase, topical or systemic steroids, hydrocolloid dressings, local infection prophylaxis and treatment should be considered for skin treatment (10).

Specialised treatment such as cytokine therapy, blood transfusions and stem cell transplantation should be considered and implemented according to necessity in a specialist environment (9).

CONCLUSIONS

Radiation accidents are rare, however, the number of accidents and incidents have increased internationally. The health care management of patients exposed to radiation is complex and demands a well coordinated

multidisciplinary effort. Therefore, it is necessary that health care personnel have some knowledge of the effects and management of radiation injury.

The fact that the effects of radiation occur after a time period indicates that the primary responsibility of emergency workers at the incident is to determine through well documented information and monitoring the presence and levels of radiation, while treatment will primarily occur at hospital level.

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Continuous Professional Development

Questionnaire 1

INSTRUCTIONS

- All health care professionals are required to collect a prescribed number of CPD points annually to register with the Statutory Council. Although this requirement is not yet formalised for the nursing professions, it is advised that the questionnaire be completed.
- Study all the articles in the journal. Complete the questionnaire at the back of the journal and return it to:

  School for Military Health Training
  Private Bag X 1022
  Thaba Tshwane
  0143
- Three (3) CPD points will be awarded to candidates who obtain more than 80% in the open book completion of the questionnaire.

Basic Mechanical Ventilation in the Operational Theatre

1. The three (3) basic variables necessary to ventilate a patient are:

   i. Oxygen
   ii. CO_2
   iii. Frequency
   iv. Volume
   v. Humidification

A i, ii, iii
B ii, iv, v
C i, ii, v
D i, iii, iv

E i, ii, iv

2. In order to mechanically ventilate an 85 kg patient on the battlefield, a tidal volume (V_T) setting of __________ will be set.

A 85 ml
B 850 ml
C 8.5 l
D 680 ml
E 6.8 l

3. In order to effectively increase the alveolar ventilation, __________ will be increased.

A Frequency
B Tidal Volume (V_T)
C Oxygen percentage
D CO_2
E Humidification

4. In order to prevent barotrauma to a mechanically ventilated patient in austere conditions, the peak inspiratory pressure (PIP) maximum setting on the ventilator should not exceed:

A 15 cmH_2O
B 30 cmH_2O
C 40 cmH_2O
D 50 cmH_2O
E 60 cmH_2O

5. A possible side effect of initiating positive end expiratory pressure (PEEP) for mechanically ventilated patients on the battlefield is:

A Increased haemoglobin saturation
B Decreased incidence in pneumothorax
C Decreased intra cranial pressure (ICP)
D Decreased venous return
E Increased peripheral cyanosis

Health Care Management of Radiation Casualties

6. The effects of ionising radiation can be influenced by:
   i. Dose received
   ii. Distance from source
   iii. Duration of exposure
   iv. Personal exercise habits
   v. Regular use of antibiotics

A i, ii, iii
B i, ii, v
C Only i
D Only iii
E All of the above

7. Which of the following tests could be deemed most useful to evaluate bone marrow depression during Acute Radiation Syndrome (ARS)?

A Liver function test (LFT)
B Full blood count (FBC)
C Peripheral blood smear
D Bone Marrow biopsy

E Long bone X-rays

8. Decontamination of radiological contaminated patients takes preference to ensuring an adequate airway.

A True
B False

Airway Management in the Military Environment

9. In order to clear a casualty's airway from visible foreign bodies on the battlefield, the airway can be swept with a gloved finger.

A True
B False

10. A casualty with a suspected cervical spine injury should be turned on his side while maintaining inline cervical stabilisation in order to clear the airway when he starts to vomit.

A True
B False

11. Which of the following is NOT considered a reason for ineffective bag-valve-mask ventilation?

A Poor mask seal
B Foreign body in the airway
C Ineffective jaw thrust manoeuvre
D Obstruction by another upper airway adjunct
E Oxygen concentration less than 100%

12. A nasopharyngeal airway can be used in a patient with a gag reflex.

A True
B False

13. The only safe airway that will prevent aspiration is a

A Cuffed endotracheal tube
B Oropharyngeal tube
C Laryngeal mask airway (LMA)
D Partial rebreather mask
E Nasopharyngeal airway of the correct size

14. While providing care under direct fire, airway management takes preference to all other aspects.

A True
B False

Haemostatic Technologies to Control Bleeding on the Battlefield

15. An incorrectly applied tourniquet can cause more bleeding.

A True
B False

16. Which of the following is NOT recommended during the use of a tourniquet?

A Cover the tourniquet after application
B Record the use of a tourniquet in an obvious place
C Remove the tourniquet at the first **appropriate** opportunity

D Use a wide tourniquet

E Ensure that other medical personnel along the line of evacuation know that a tourniquet has been applied.

17. Which of the following is NOT considered a **basic** activity to control bleeding by every soldier before applying a tourniquet?

A Direct pressure

B Application of a dressing

C Establishing an intravenous line

D Elevation of a limb

E Pressure on a pressure point

Vehicle Extrication on the Battlefield

18. The basic sequence of vehicle extrication on the battlefield (not under direct fire) is:

A Scene size-up; Patient access; Disentanglement; Packaging; Extrication

B Scene size-up; Patient access; Disentanglement; Extrication; Packaging

C Patient access; Scene size-up: Disentanglement; Extrication; Packaging

D Disentanglement; Extrication; Packaging; Patient Access; Scene size-up

E Scene size-up; Patient access; Extrication; Disentanglement; Packaging

19. After all-round defence is in place, the battle vehicle's own weapons are deemed the immediate threat to the rescuers' safety.

A True

B False

20. If an emergency extrication is not indicated, immobilisation prior to movement is considered the basic concept.

A True

B False

Continuous Professional Development

Questionnaire 2

Triage

INSTRUCTIONS

- All health care professionals are required to collect a prescribed number of CPD points annually to register with the Statutory Council. Although this requirement is not yet formalised for the nursing professions, it is advised that the questionnaire be completed.
- Study all the articles in the journal. Complete the questionnaire at the back of the journal and return it to:

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Triage each of the following patients according to Triage SIEVE and Triage SORT

Patient No: 1

Picture: www.petervanagtmael.com

- **History:** A soldier with a shrapnel wound to left temporal.
- **Mobility:** Was walking requested to lie down
- **Airway:** Open
- **Skin:** Pale
- **Breathing Quality:** Normal
- **Breathing Rate:** 18/min
- **Pulse Quality:** Normal
- **Pulse Rate:** 124/min
- **Blood Pressure:** 120/80 mmHG
- **Findings:** Shrapnel wound to the head. Not penetrated the skull.
- **Neurological Status:** Orientated; complains of a serious headache; feels pain; obeys commands; opens eyes spontaneously; pupils equal and reacting to light.

- **Fluid Requirement**: 1 Litre
- **Blood Requirement**: 0 Units
- **Blood Group**: A Pos
- **Theatre Time**: 0 Hours 30 Min Level 2

Patient No: 2

Picture: www.motherjones.com

- **History:** A 21-year-old soldier that was involved in a mortar explosion.
- **Mobility:** Sitting
- **Airway:** Open, but spitting out blood
- **Skin:** Pale, cool and moist
- **Breathing Quality:** Normal
- **Breathing Rate:** 32/min
- **Pulse Quality:** Normal
- **Pulse Rate:** 115/min
- **Blood Pressure:** 115/75 mmHG
- **Findings:** Multiple small shrapnel wounds to face: forehead, left eye, upper lip and cheek. Bleeding from left ear.
- **Neurological Status:** Seems orientated; but does not respond to verbal stimuli or any questions; feels pain; pupils equal and reacting normally; says in a monotonous voice that he cannot hear.

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 0 Units
- **Blood Group**: O Pos
- **Theatre Time**: 1 Hours 0 Min
- **Require**: CT Scan/ Head x-ray

Patient No: 3

Picture: http://miroakley.com

- **History:** A 19-year-old soldier that was involved in a hand grenade explosion.
- **Mobility:** Walking
- **Airway:** Open
- **Skin:** Pale and warm
- **Breathing Quality:** Regular
- **Breathing Rate:** 22/min
- **Pulse Quality:** Normal
- **Pulse Rate:** 136/min
- **Blood Pressure:** 120/80 mmHG
- **Findings:** Small shrapnel wounds over face. Dark glasses dotted with marks.
- **Neurological Status:** Orientated; talking; feels pain; obeys commands; pupils equal and reacting to light; indicated that he lost consciousness for about 5 min after the incident.

- **Fluid Requirement**: 0 Litre
- **Blood Requirement**: 0 Units
- **Blood Group**: O Pos
- **Theatre Time**: 0 Hours 0 Min

Patient No: 4

Picture:www.al-ghoul.com

- **History:** A 19-year-old soldier involved in an explosion of an unknown explosive device.
- **Mobility:** Lying
- **Airway:** Open
- **Skin:** Warm and pale
- **Breathing Quality:** Shallow and fast
- **Breathing Rate:** 34/min
- **Pulse Quality:** Shallow and fast
- **Pulse Rate:** 116/min
- **Blood Pressure:** 110/70 mmHG
- **Findings:** Complains of shortness of breath. Right side of chest dull on percussion. Trachea central no neck vein distension.
- **Neurological Status:** Orientated; opens eyes spontaneously; obeys commands; pupils equal and reacting to light.
- Medic established 1 x Peripheral line right arm.

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 2 Units
- **Blood Group**: O Pos
- **Theatre Time**: 0 Hours 30 Min
- **X-Ray**: Massive Right Heamo Thorax

Patient No: 5

Picture: H. Havenga

- **History:** A Rooikat driver hit by a missile of unknown type.
- **Mobility:** Extricated through the emergency door and placed on a stretcher.
- **Airway:** Open
- **Skin:** Warm and normal
- **Breathing Quality:** Normal
- **Breathing Rate:** 22/min
- **Pulse Quality:** Normal
- **Pulse Rate:** 94/min
- **Blood Pressure:** 120/70 mmHG
- **Findings:** Shrapnel wound to lower abdomen.
- **Neurological Status:** Disorientated and confused; opens eyes on voice; obeys commands; pupils equal and reacting to light.

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 2 Units
- **Blood Group**: A Pos
- **Theatre Time**: 1 Hours 0 Min

Patient No: 6

Picture: P.van Aswegen

- **History:** A bombardier with a shrapnel wound to left lower quadrant of the abdomen.
- **Mobility:** Removed from armoured vehicle and lying on a stretcher.
- **Airway:** Open
- **Skin:** Warm and normal
- **Breathing Quality:** Normal
- **Breathing Rate:** 18/min
- **Pulse Quality:** Normal
- **Pulse Rate:** 84/min
- **Blood Pressure:** 120/80 mmHG
- **Findings:** Shrapnel wound visible. No active bleeding.
- **Neurological Status:** Orientated; opens eyes spontaneously; obeys commands.

B+C/B

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 0 Units
- **Blood Group**: A Pos
- **Theatre Time**: 1 Hours 0 Min

Patient No: 7

Picture: www://kingmagic.files.worldpress.com

- **History:** A 21-year-old infantry soldier that was involved in an artillery shell explosion near his position.
- **Mobility:** Lying
- **Airway:** Compromised
- **Skin:** Cool, moist, ashen grey
- **Breathing Quality:** Rapid, deep, regular
- **Breathing Rate:** 22/min
- **Pulse Quality:** Rapid, strong, regular.
- **Pulse Rate:** 96/min
- **Blood Pressure:** 130/85 mmHG
- **Findings:** Open fracture to skull.
- **Neurological Status:** Making incomprehensible sounds; withdraw on pain and open eyes only on pain; pupils equal and reacting to light.

B+B

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 0 Units
- **Blood Group**: A Pos
- **Theatre Time**: To be determined

Patient No: 8

Picture: http://timesonline.co.uk

B+C/B

- **History:** A 27-year-old corporal that was involved in a shelling incident with enemy forces.
- **Mobility:** Sitting
- **Airway:** Open
- **Skin:** Warm, with burns to the chest and arms, all exposed areas keep on burning with smoke appearing from burning flesh
- **Breathing Quality:** Normal
- **Breathing Rate:** 18/min
- **Pulse Quality:** Rapid and full
- **Pulse Rate:** 92/min
- **Blood Pressure:** 120/80 mmHg
- **Findings:** When lights are switched off, the burns glow in a greenish colour in the dark.
- **Neurological Status:** Awake

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 0 Units
- **Blood Group**: B Pos
- **Theatre Time**: 0 Hours 0 Min

Patient No: 9

Picture: http://z.bp.blogspot.com

- **History:** A Medic of a foot patrol involved in an IED explosion.
- **Mobility:** Lying in a bundle in a groundsheet carried by the members of the foot patrol
- **Airway:** Seriously compromised; gurgling.
- **Skin:** Cold and moist
- **Breathing Quality:** Shallow with gurgling noises
- **Breathing Rate:** About 8/min
- **Pulse Quality:** Weak; rapid; regular.
- **Pulse Rate:** 128/min
- **Blood Pressure:** 100/60 mmHG
- **Findings:** Shrapnel wounds to abdomen, both legs and left arm. Several pieces of shrapnel penetrated the abdomen. Soldiers give information that IED contained numerous nails and nuts.
- **Neurological Status:** Opens eyes only to painful stimuli; trying to talk; withdraw from painful stimuli, both pupils dilated.

- **Fluid Requirement**: 4 Litre
- **Blood Requirement**: 4 Units
- **Blood Group**: O Pos
- **Theatre Time**: 2 Hours 45 Min (Level 2)

Patient No: 10

Picture: http://icechewing.huddler.com

- **History:** An 18-year-old Commander of a Rooikat armoured vehicle involved in a collision while travelling at high speed.
- **Mobility:** Extricated and placed on stretcher
- **Airway:** Compromised
- **Skin:** Blue and cold
- **Breathing Quality:** Fast, shallow and laboured
- **Breathing Rate:** 28/min
- **Pulse Quality:** Fast; rapid; regular
- **Pulse Rate:** 144/min
- **Blood Pressure:** 100/60 mmHG
- **Findings:** Multiple chest and abdominal injuries; pneumothorax right; abdomen tender over upper right quadrant.
- **Neurological Status:** Opens eyes to voice; inappropriate answers to questions; moves arms and legs on requests.

- **Fluid Requirement**: 2 Litre
- **Blood Requirement**: 3 Units
- **Blood Group**: O Pos
- **Theatre Time**: 1 Hours 45 Min (Level 2)

SOUTH AFRICAN MILITARY HEALTH SERVICE

MILMED Scientific: Operational Medicine

CPD Answer Sheet No 1

Demographics:

Force Number: ____________________ Rank: __________

Initials and Surname: ____

HPCSA/SANC Registration Number: ______________________________

Unit: ____

Postal Address: ____

____

____

____

____

Signature: ___________________________ Date: ___________

Answers:

1	A	B	C	D	E
2	A	B	C	D	E
3	A	B	C	D	E
4	A	B	C	D	E
5	A	B	C	D	E
6	A	B	C	D	E
7	A	B	C	D	E
8	A	B	C	D	E
9	A	B	C	D	E
10	A	B	C	D	E

11	A	B	C	D	E
12	A	B	C	D	E
13	A	B	C	D	E
14	A	B	C	D	E
15	A	B	C	D	E
16	A	B	C	D	E
17	A	B	C	D	E
18	A	B	C	D	E
19	A	B	C	D	E
20	A	B	C	D	E

SOUTH AFRICAN MILITARY HEALTH SERVICE

MILMED Scientific: Operational Medicine

CPD Answer Sheet No 2

Demographics:

Force Number: ____________________ Rank: ___________

Initials and Surname: ____

HPCSA/SANC Registration Number: _______________________________

Unit: ____

Postal Address: ____

____

____

____

____

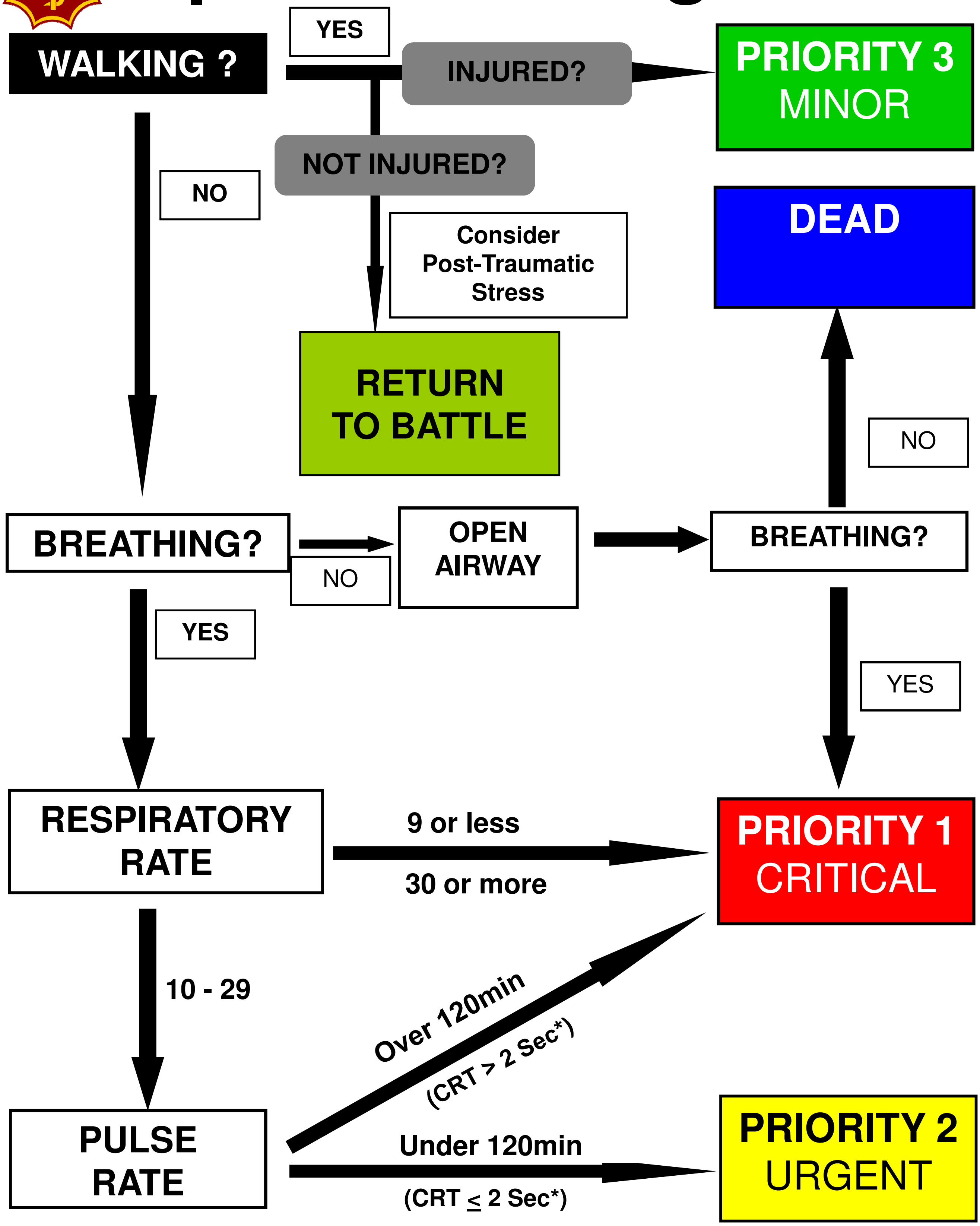
Signature: ____________________________ Date: ____________

Answers: Indicate the Triage priority for each patient, e.g. P1, P2, P3, P4, Dead

Patient No	Triage SIEVE	Triage SORT
1		
2		
3		
4		
5		

Patient No	Triage SIEVE	Triage SORT
6		
7		
8		
9		
10		

Operation Triage: Sieve



*: Capillary Refill Time (CRT) is an alternative to pulse rate, but is unreliable in the cold or dark: if it is used, a CRT of > 2 seconds indicates **PRIORITY 1**

Triage Level 1 and 2: Sort

STEP 1: Calculate the GLASGOW COMA SCORE (GCS)

A: Eye opening:

Spontaneous	4
To Voice	3
To Pain	2
None	1

B: Verbal response:

Orientated	5
Confused	4
Inappropriate	3
Incomprehensible	2
No Response	1

C: Motor response:

Follows command	6
Localise Pain	5
Withdrawal to pain	4
Flexion to pain	3
Extension to pain	2
No Response	1

Glasgow Coma Score (GCS) = A + B + C

STEP 2: Calculate the TRIAGE SORT SCORE

X: Convert Glasgow Coma Scale

13 – 15	4
9 – 12	3
6 – 8	2
4 – 5	1
3	0

Y: Respiratory Rate

10 – 29	4
> 29	3
6 – 9	2
1 – 5	1
0	0

Z: Systolic Blood Pressure

$\geq$ 90	4
76 – 89	3
50 – 75	2
1 – 49	1
0	0

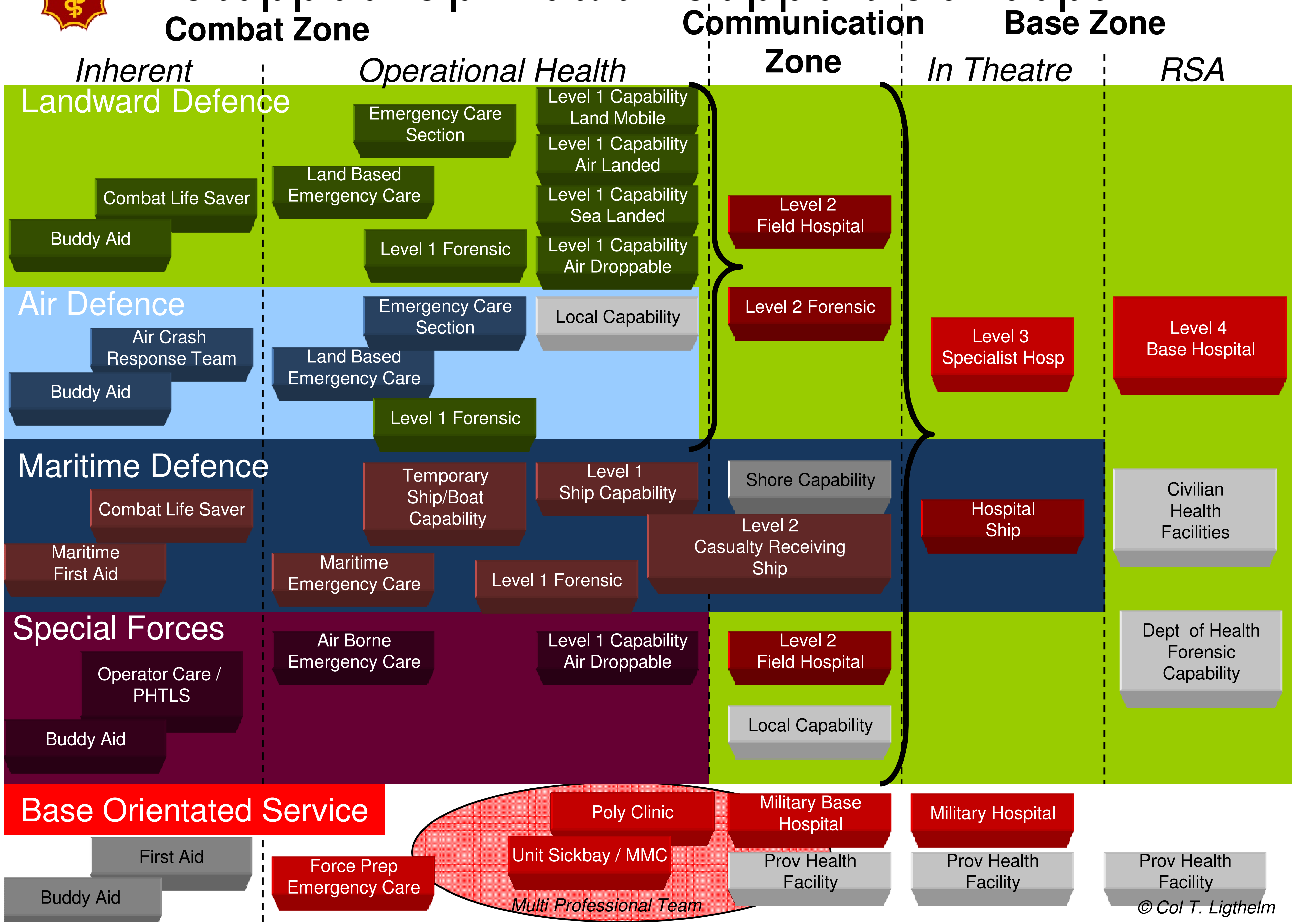
Triage Sort Score = X + Y + Z

STEP 3: Assign a triage PRIORITY

12	=	**Priority 3 - Minor**
11	=	**Priority 2 - Serious**
$\leq$ 10	=	**Priority 1 - Critical**
0	=	**Dead**

STEP 4: Upgrade PRIORITY, dependent on the injury/ diagnosis

Stepped-Up Health Support Concept



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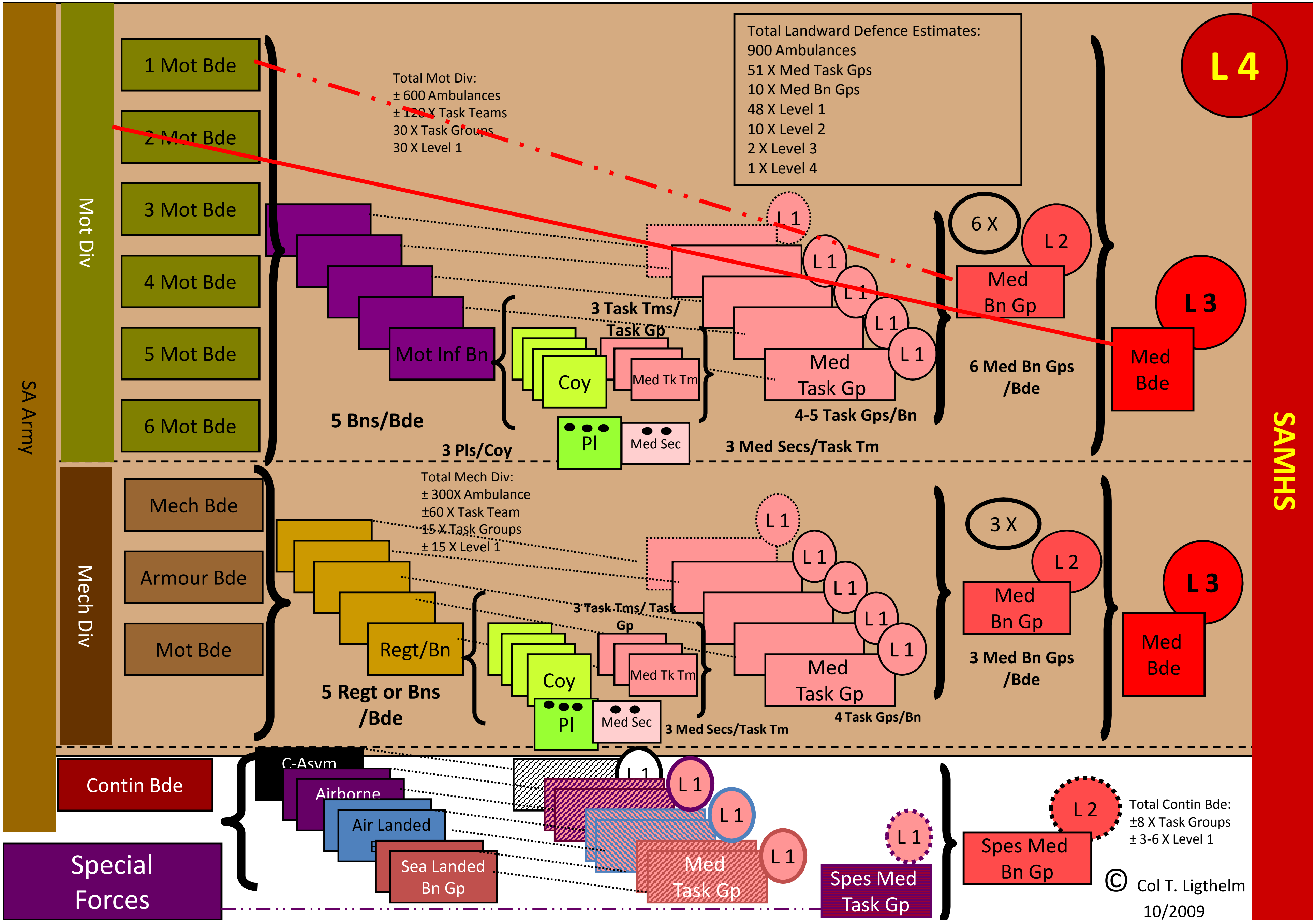
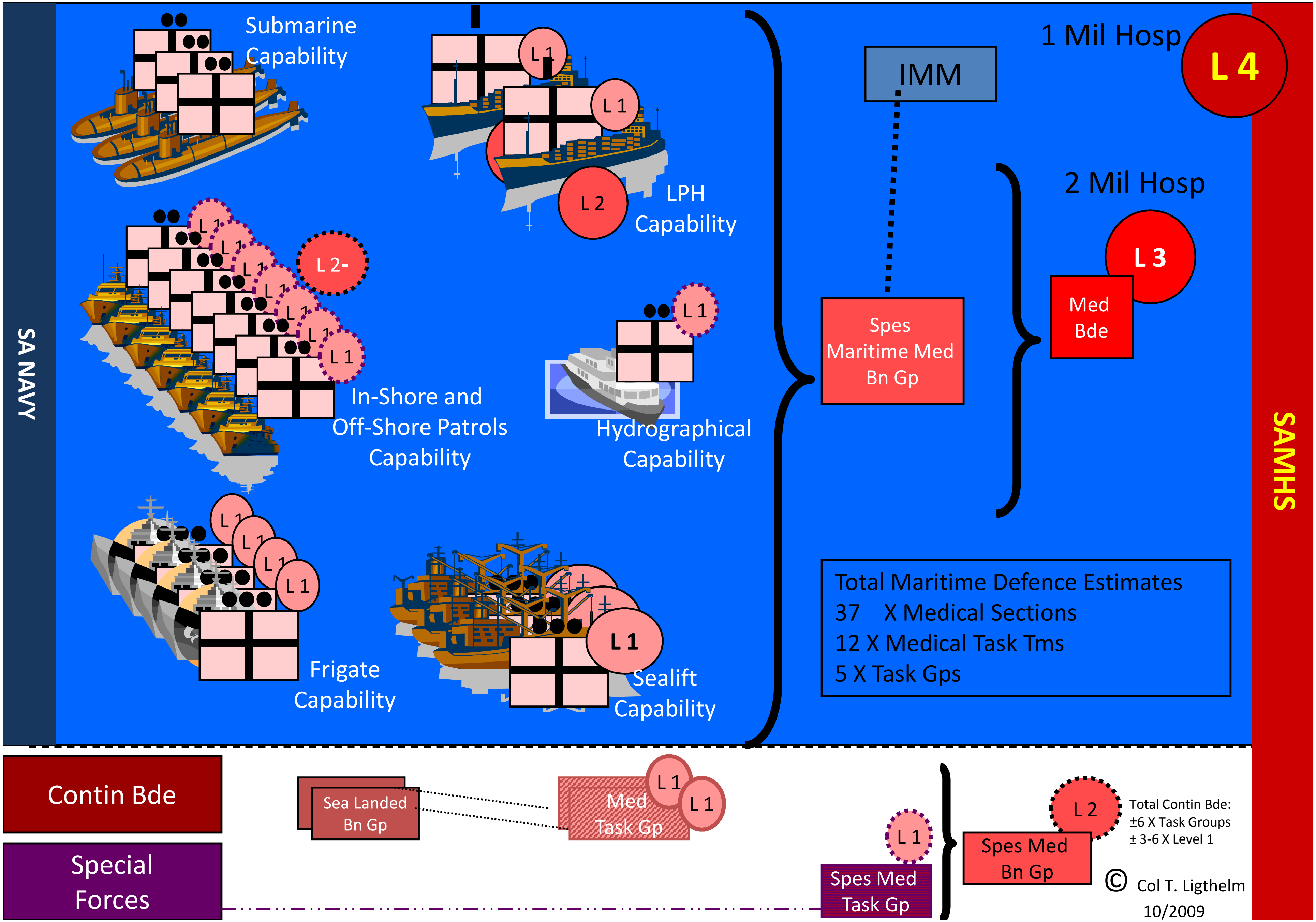
Military Health Landward Defence Support Doctrine



Military Health Maritime Defence Support Doctrine



Military Health Air Defence Support Doctrine